Accepted Manuscript

Medicinal uses, phytochemistry and pharmacology of family Sterculiaceae: A review

L.M.R. Al Muqarrabun, N. Ahmat

PII: S0223-5234(15)00046-X

DOI: 10.1016/j.ejmech.2015.01.026

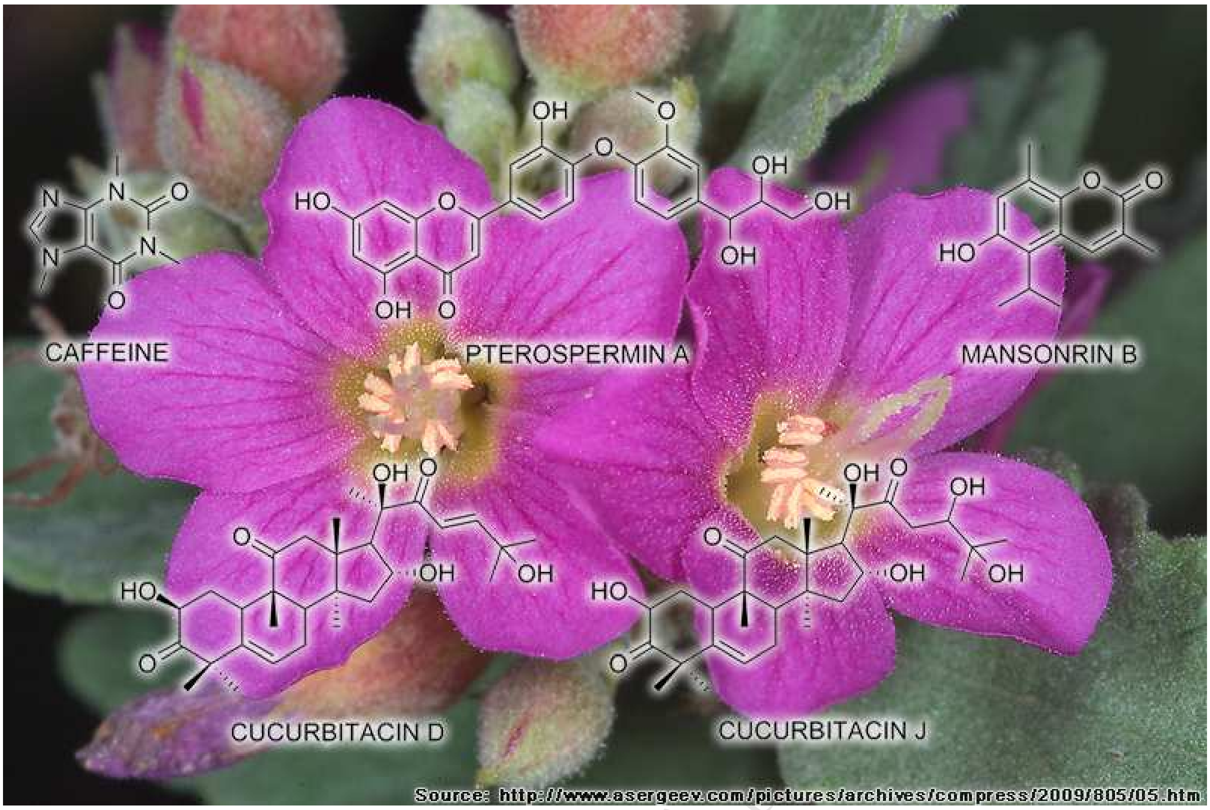
Reference: EJMECH 7642

To appear in: *European Journal of Medicinal Chemistry*

Received Date: 2 December 2014

Revised Date: 8 January 2015

Accepted Date: 12 January 2015


CAFFEINE
PTEROSPERMIN A
MANSONRIN B
CUCURBITACIN D
CUCURBITACIN J
Source: http://www.asergeev.com/pictures/archives/compress/2009/805/05.htm

Review

Medicinal uses, phytochemistry and pharmacology of family Sterculiaceae: A review

L.M.R. Al Muqarrabun, N. Ahmat*

Faculty of Applied Sciences, Universiti Teknologi MARA (UiTM), 40450 Shah Alam, Selangor, Malaysia

*Corresponding author: Tel: +60355444643, Fax: +60355444562

E-mail address: noriz118@salam.uitm.edu.my (Norizan Ahmat)

Abstract

The Family Sterculiaceae is one of the most important families among flowering plants. Many of its members demonstrate medicinal properties and have been used for the treatment of various ailments and wounds. A wide range of compounds including alkaloids, phenyl propanoids, flavonoids, terpenoids and other types of compounds including hydrocarbons, sugars, quinones, phenolic acids, lactones, lignans, amine and amides have been isolated from several species in this family. Few studies have reported that some extracts and single compounds isolated from this family exhibited several biological activities, such as antimicrobial, anti-inflammatory, antioxidant and cytotoxic activities. The present review is an effort to provide information about the traditional uses, phytochemistry and pharmacology of species from family Sterculiaceae, and to uncover the gaps and potentials requiring further research opportunities regarding the chemistry and pharmacy of this family.

Keywords: Sterculiaceae, alkaloids, flavonoids, terpenoids, antimicrobial, cytotoxicity

Contents

1. Introduction

Sterculiaceae has previously been recognized as a family by most systematists. The family comprises 70 genera, totalling around 1,500 species of tropical trees and shrubs, or lianas or herbs. The most famous products of the family are chocolate and cocoa from *Theobroma cacao*, not to mention the cola nuts. Many species of this family are reported to yield timber [1, 2].

The leaves are alternate and simple or infrequently palmately lobed or compound; stipules are present but they are shed early. The flowers are actinomorphic or rarely zygomorphic, and are bisexual or not uncommonly functionally unisexual. The perianth is commonly uniseriate, consisting of 3-5 valvate, basally connate sepals, but sometimes an equal number of petals are also present. The androecium most frequently consists of two whorls of 5 stamens each, these are united by their filaments into a tube that commonly surrounds the ovary or arises from an androgynophore. The gynoecium consists of a single compound pistil of usually 4-5 sometimes weakly associated carpels, an equal number of distinct or variously connate styles, and a superior ovary with usually 4-5 locules, each with 2-several axile ovules. The fruit is variable; sometimes the carpels are completely distinct at maturity [3].

Several species from family Sterculiaceae have been applied as traditional medicines in various countries for decades to treat a broad spectrum of ailments and diseases. A number of researchers have conducted studies on the chemical constituents and pharmacological properties of several species from this family. This review describes the phytochemical and pharmacological properties of species from family Sterculiaceae. The phytochemical studies have resulted in the isolation of more than 170 compounds consisting of various classes of compounds including alkaloids, phenyl propanoids, flavonoids and terpenoids. However, the pharmacology of this family has not been widely investigated. Even though many species of this family have been discovered and identified, only a few numbers of species that have been studied about the antimicrobial, anti-inflammatory and cytotoxicity of the various extracts. In addition to that, of about 170 compounds identified from this family, only approximately 25 compounds have been subjected to bioactivity assays including antibacterial, antioxidant and cytotoxicity. Moreover, no toxicity studies of both the extracts and chemical constituents of this family have been analyzed. These gaps open up a great research opportunity to study more about the phytochemical and pharmacology of family Sterculiaceae considering the interesting medicinal properties possessed by species and the chemical constituents of this family. Since a vast number of species from different genus in this family have not been explored yet, there are very significant opportunities to find novel compounds as well as promising medicinal and pharmacological properties from various extracts of the species. This can also lead to possibilities of finding new sources of drugs for future applications.

2. Medicinal Uses of Some Species from Family Sterculiaceae

Plants from family Sterculiaceae have long been used as traditional medicine in several countries and tribes. Almost all parts of the plants including root, bark, and leaf of the species from the family were reported to exhibit a broad range of medicinal properties (Table 1). The root part of *Ambroma augusta* Linn. F., commonly known as "Ulatkambal", is used for the treatment of dysmenorrhea, amenorrhea sterility and other menstrual disorders in India [4]. The Mixe Indians tribe in Mexico has used the bark of *Guazuma ulmifolia* Lam. to treat diarrhea [5]. In Indonesia, the fruit of *Helicteres isora* L., locally known as "Ulet-Ulet", is a raw material for the production of "Jamu" [6], while its root is used in China as a remedy for treating snake bites, nephritis and gastric ulcers [7].

Some species from the Genus *Melochia* were reported to possess anti-inflammatory property. It was reported by Bhakuni et al. [8] that a decoction of *Melochia corcholifolia* has been used as a cure for abdominal swelling. Shukla et al. [9] reported that a decoction of the leaf or root of another species from the genus, *Melochia tomentosa*, is recommended for the relief of throat inflammation in Curacao, Venezuela.

Table 1
Medicinal Uses of Some Sterculiaceae Species

Respiratory-related diseases have long been treated using species from this family. *Semen Sterculiae Lychnophorae* is used for clearing phlegm (by "clearing heat from the lungs" as explained in Chinese medicine) and relieving sore throat to restore the voice on the upper respiratory tract [10]. The whole parts of *Waltheria dourandinha* St. Hil. are used to treat respiratory disorders and are also used effectively as a stimulant, emetic, and diuretic, urinary diseases and, externally and as a wound cleansing and healing agent [11-13]. Chronic diseases such as cancer [14], tumor [15], diabetes [16], and kidney disease [17] have also been reported to be treatable using traditional medicine from some species of family Sterculiaceae.

3. Chemical Constituents of Some Species from Family Sterculiaceae

Family Sterculiaceae contains various classes of compounds. As far as the studies about the phytochemistry of this family are concerned, compounds from family alkaloid, flavonoid and its derivatives, and terpenoid and its derivatives predominate in most of the species have been studied. Other than the compounds classes mentioned, Sterculiaceae family also comprises of other classes such as phenyl propanoid and its derivatives, lignans and some phenolic acids.

3.1 Alkaloids

Several alkaloids have been isolated from some species of family Sterculiaceae (Table 2). This family contains different types of alkaloids, such as cyclopeptide alkaloids, quinolone alkaloids, purine alkaloids, and pseudooxindol alkaloid, distributed in entire parts of plants from different genus and species.

Most of cyclopeptide alkaloids isolated from this family were reported to be obtained from the Genus *Melochia* and *Waltheria*. Kapadia et al. [18] isolated three of those compounds, scutianine B (**4**) and two new cyclopeptide alkaloids, melanovine A (**6**) and B (**7**), from the root of *Melochia tomentosa*. Ten years later, frangufoline (**3**), franganine (**12**) and melafoline (**13**) were isolated from *Melochia corchorifolia* leaf [8]. Melofoline was isolated as a new compound. In 1999, [19]and co-workers reported the occurrence of three new cyclopeptide alkaloids, waltherine A, B, and C (**8**-**10**, respectively), and one known alkaloid, adouetine Y (**11**), from the bark of *Waltheria douradinha*. In the same year, El-Seedi et al. [20] isolated new compounds, which are integerrenine (**14**), and anorldianine 27-*N* oxide (**15**) from the bark of *Heisteria nitida*. Another report about the existence of cyclopeptide alkaloids in Genus *Melochia* was made by Dias et al. [14] by isolating chamaedrin, adouetine X and scutianine C (**1**, **2**, and **5**, respectively) from the bark of *Melochia chamaedrys*. Chamaedrin was isolated for the first time in the work.

Table 2
Alkaloids from Sterculiaceae Species

Just like the cyclopeptide alkaloids, the quinolone alkaloids were also found only in Genus *Melochia* and *Waltheria*. Waltherione A (**16**) occurs in *Melochia chamaedrys* root and the bark of *Waltheria douradinha* [14, 21, 22]. From the stem part of *Waltheria douradinha*, Gressler et al. [22] managed to isolate waltherione B (**17**), vanessine (**22**) and antidesmone (**23**). In that work, only waltherione B and vanessine that were reported for the first time. In 1978, Kapadia [23]and his group found a new quinolone alkaloid, melovinone (**19**), along with three other quinolone alkaloids, melochinone, melosatin A and B (**18**, **20**, and **21**, respectively), from the roots of *Melochia tomentosa*.

The other types of alkaloids were also found in some species from family Sterculiaceae. Melochicorine (**26**), a new pseudooxindol, was obtained by Bhakuni et al. [24] from the leaf of *Melochia corchorifolia*. In 2003, Wang [25] and co-workers successfully isolated two new alkaloid, sterculinine I and II (**24** and **25**, respectively) from the seed of *Sterculia lychnophora* Hance. Three common purine alkaloids, caffeine, theobromin and theacrine (**28-30**, respectively), have been identified to occur in several species from Genus *Theobroma* and *Herrania* by Hammerstone et al. [26]. The alkaloids isolated from family Sterculiaceae are illustrated in Figure 1.

Figure 1. Alkaloids from Sterculiaceae Species

3.2 Phenyl Propanoids

Family Sterculiaceae comprises three major classes of phenyl propanoid, i.e. cinnamic acid, coumarin, and tocopherol derivatives (Table 3). Two common cinnamic acid derivatives, *p*-coumaric acid (**33**) and caffeic acid (**34**), and two quinic acid-containing cinnamic acid derivaties, *p*-coumaroylquinic acid (**37**) and chlorogenic acid (**38**), were isolated from the leaf of *Theobroma cacao* by Jalal and Collin [27]. In 2006, Chen [28] and his group isolated two other cinnamic acid derivatives from *Helicteres angustifolia* leaf, coniferol (**35**) and 3-(3,4-dimethoxyphenyl)-2-propenal (**36**).

Table 3
Phenyl Propanoids from Sterculiaceae Species

Coumarin-related compounds dominate the distribution of phenyl propanoid derivatives in family Sterculiaceae. In a study conducted on the heartwood of *Scaphopetalum thonneri* by Vardamides et al. [29], the compounds scopolin (**39**) and scopoletin (**40**) were obtained. In 2002, Tiew [30] and his colleagues reported three new coumarins, which are mansonrin A-C (**41**-**43**), that occur in *Mansonia gagei* heartwood. In other study, Bruni et al. [31] isolated four types of tocopherol, α, β, γ and δ tocopherol (**48**-**51**, respectively), from the seed of *Theobroma subincanum*. The phenyl propanoid derivatives of family Sterculiaceae are depicted in Figure 2.

Figure 2. Phenyl Propanoids from Sterculiaceae Species

3.3 Flavonoids

Flavonoids of this family comprise flavones, flavans and their derivatives (Table 4). Simple flavones such as apigenin (**52**) and 3'-methoxyapigenin (**53**) were isolated from *Pterospermum acerifolium* Willd*.* flower [16], while simple flavans such as (+)-catechin (**78**), (-)-epicatechin (**79**), and leucocyanidin (**81**) were found in *T. cacao* leaf/bean [27, 32]. The glucoside derivative of apigenin, luteolin and quercetin were reported to occur in the leaf of *T. cacao* [27], while their neohesperidoside were successfully isolated from *P. acerifolium* Willd*.* flower by Dixit et al. [16]. In addition to the two glycosides, the other types of glycoside of the other flavones, including galactoside, arabinoside, rutinoside and glucuronide also exist in several species from this family. They are distributed in various parts of the plant including roots, leaves, flowers and fruits [16, 25, 27, 28, 32]. In 2001, Kamiya [6] and co-workers managed to isolate four new unusual flavone glucuronides from the fruit of *Helicteres isora* (**72**-**75**), three of which contains sulphate groups (Figure 3).

Table 4
Flavonoids from Sterculiaceae Species

Figure 3. Flavones from Sterculiaceae Species

Flavan group in this family is dominated by its oligomers, including dimer, trimer and tetramer (**84**-**102**). Interestingly, as far as the authors are concerned, all the flavan oligomers were isolated only from *T. cacao* bean, and those works were done only by Porter et al. [33] and Hatano et al. [32]. From the leaf of *T. cacao*, two anthocyanidin glycosides named cyanidin-3-galactoside (**103**) and cyanidin-3-arabinoside (**104**) were also reported by Lowry [34]. Figure 4 shows the flavans isolated from family Sterculiaceae.

Figure 4. Flavans from Sterculiaceae Species

3.4 Terpenoids

The terpenoid compounds in this family are dominated by sesquiterpenes and triterpenes. Table 5 describes the terpenoids found in family Sterculiaceae. There are only two reported monoterpenes from this family, (6*R*,9*S*)-3-oxo-α-ionol-β-ᴅ-glucopyranoside (**105**) and linalool-3-rutinoside (**106**). They were isolated from the flower of *Pterospermum acerifolium* Willd*.* [16]. Most of the sesquiterpenes in this family, such as mansonone C, E, F, G, H, M, R, S and mansonone H methyl ester were found in *Helicteres angustifolia* and the heartwood of *Mansonia gagei* [28, 30, 35, 36]. Two other sesquiterpenes named 7-hydroxycalamenene (**116**) and its dimer, 8-bis(7-hydroxycalamenene) (**118**) were isolated by Cambie et al. [37] from *Heritiera ornithocephala* heartwood along with 8-hydroxy-2,3,4,5-tetrahydro-2,7,11,11-tetramethyl-1-benzox-epin-4-one (**117**). The only diterpene found in this family was 2α,7β,20α-trihydroxy-3β,21-dimethoxy-5-pregnene which was reported by Chen et al. [28] to exist in *H. angustifolia* root.

Table 5
Terpenoids from Sterculiaceae Species

There are more than 20 triterpenoids belonging to class lupane, friedelane, oleanane and steroid that have been found in family Sterculiaceae. El-Seedi et al. [20] obtained lupeol (**121**) from *Heisteria nitida*, while its derivatives, **122**-**128**, were reported to occur in the root of *H. angustifolia* [28, 38]. In 1972, Rizvi and Sultana [39] isolated two fridelane-type triterpenes, fridelan-3α-ol (**129**) and fridelan-3-β-ol (**130**), from *P. acerifolium* Willd. flower. A new olenanane triterpene named scaphopetalumate (**133**) was isolated from the bark of *Scaphopetalum thonneri* by Vardamides et al. [29] along with oleanolic acid (**132**). A study on *Herrania cuatrecassana* stem by Wiedemann et al. [40] resulted in the isolation of two new unusual oleanane-type triterpenes, Herranone (**135**) and herrantrione (**136**). Three new cycloartane-type triterpenes, cyclopterospermol, 30-norcyclopterospermol and 30-norcyclopterospermone (**140**-**142**, respectively), were found in the

stem of *Pterospermum heyneanum* [41]. Not only lupane-type triterpenes, Chen et al. [28] also successfully isolated two new cycloartane derivatives, cucurbitacin D and J (**143** and **144**, respectively) from *H. angustifolia* root.

Besides those triterpenes mentioned above, steroids were also found in some species from family Sterculiaceae. β-sitosterol (**145**) and its acetate derivative (**146**) were isolated from certain parts of some species [20, 25, 28, 42], while stigmasterol (**147**) and its glucoside derivative (**148**) were reported by El-Seedi et al. [20], Alam et al. [4] and Wang et al. [25]. Figure 5 depicts the triterpenoid compounds isolated in species of family Sterculiaceae.

Figure 5. Terpenoids from Sterculiaceae Species

3.5 Miscellaneous Compounds

Species from this family were also reported to contain several compounds from other classes, as shown in Table 6. Two quinone, 3-hydroxy-5-methoxy-2-methylbenzoquinone (**157**) and heliquinone (**158**), were isolated from *P. heyneanum* stem [41] and *H. angustifolia* root [43], respectively. Chen et al. [28] reported the occurrence of four lignans (**168**-**170**) from *H. angustifolia* root, while lignin **171** and **172** were obtained from *Scaphopetalum thonneri* bark [29] and the stem of *Mansonia gagei* [35]. In 2005, Seigler et al. [44] succeeded in isolating two cyanogenic glycosides, (2*R*)-taxyphillin (**173**) and (2*S*)-durrin (**174**), from *Guazuma ulmifolia* leaf. The structures of the compounds can be seen in Figure 6.

Table 6
Miscellaneous Compounds from Sterculiaceae Species

Figure 6. Miscellaneous Compounds from Sterculiaceae Species

4. Biological Activities of Family Sterculiaceae

Various traditional uses of plants from family Sterculiaceae have led scientists to investigate their pharmacological properties and to validate the uses of this family as therapeutic remedies. Several pharmacological activities have been reported to be exhibited by extracts (Table 7) as well as single compounds (Table 8) of some species from this family, such as antimicrobial, antioxidant, anti-inflammatory, and cytotoxicity. However, of many species that have been identified in this family, only a few have been pharmacologically studied.

Table 7
Biological Activities of Some Sterculiaceae Species

4.1 Antimicrobial

There are only several species from the family which have been tested for biological activities. Reid et al. [45] studied the antibacterial and anti-inflammatory of *Cola greenwayi, Cola natalensis, Dombeya cymosa, Dombeya burgessiae* and *Hermannia depressa*. They found that the ethyl acetate extract of *C. greenwayi* leaf and the ethanolic extract of *D. cymosa* leaf showed activity against *Staphylococcus aureus and Klebsiella pneumoniae*, while the ethanolic extract of *H. depressa* root exhibited antibacterial activity against *Bacillus subtilis*. In addition, it was revealed that both the extracts of *C. natalensis* and *D. burgessiae* leaf displayed no antibacterial activity against *Escherichia coli, B. subtilis, S. aureus* and *K. pneumoniae*. In other study, the ethanolic extract of *Guazuma ulmifolia* bark was reported to inhibit cholera toxin-induced secretion in rabbit distal colon mounted in an Ussing chamber.

Several alkaloids were found to show no antimicrobial activity. Alkaloids **6**, **7**, **9** and **10** were inactive against several bacteria strains such as S. aureus and *S. epidermidis* as well as against some fungi strains such as *Saccharomyces cereviseae* and *Candida albicans* [21, 22]. However, vanessine (**8**) was reported by Gressler et al. [22] to exhibit very low activity against *E. coli, Staphylococcus Setubal* and *K. pneumonia* with IC_{50} of 25.0, 50.0 and 25.0 μg/mL.

4.2 Anti-inflammatory

In the same study as mentioned above, Reid et al. [45] also observed the cyclooxygenase-1 (COX-1) inhibitory activity of the same species. It was found that only the extracts of *D. burgessiae, D. cymosa* and *H. depressa* which exhibited high COX-1 inhibitory activity, while the leaf extract of *C. greenwayi* and *C. natalensis* showed good and low activity in inhibiting the COX-1, respectively.

Table 8
Biological Activities of Some Compounds from Sterculiaceae Species

4.3 Antioxidant

The authors could not find any reports about the antioxidant activity of species from family Sterculiaceae. However, there is study about the antioxidant of the single compounds isolated from the *T. cacao* beans done by Hatano et al. [32]. They

investigated the lipid peroxidation inhibition, linoleic acid autooxidation inhibition and the radical scavenging (DPPH) activities of 10 flavans they managed to isolate (**79**, **80**, **87**, **88**, **96**, **97** and **99**-**102**). The study produced a report that stated that almost all of the compounds displayed high activities in the three assays tested. Compound **80** did not exhibit inhibition activity on NADPH-dependent lipid peroxidation in rat liver microsomes.

4.4 Cytotoxicity

In 2002, Tiew [30] and his group screened the cytotoxicity of hexane and dichloromethane of *Mansonia gagei* heartwood. They reported that both extracts displayed cytotoxicity against *Artemia salina* Linn. with LC_{50} of 23.69 and 22.83 μg/mL, respectively. Furthermore, they investigated the cytotoxicity of each three coumarin derivatives (**41**-**43**) and sesquiterpenes (**107**, **110** and **111**). Coumarin **42**, **41** and **43** showed high, medium and low cytotoxicity against brine shrimp *Artemia salina* Linn., respectively, while sesquiterpene **107**, **110** and **111** displayed high, medium and medium cytotoxicity. Of the six compounds tested, mansonrin B (**42**) were of the highest cytotoxicity with IC_{50} of 0.61 μg/mL. In other study, cucurbitacin D and J (**143** and **144**, respectively) were reported to show significant antitumor activity by inhibiting the proliferation of BEL-7402 and SK-MEL-28 cell lines [28]. Nevertheless, the other two triterpenes they isolated, **124** and **125**, displayed mild inhibitory activity against SK-MEL-28 cell lines.

5. Conclusion

Species from family Sterculiaceae have various and numerous traditional medicinal uses in various countries and tribes. The root, bark and leaf of the species in the family were reported to possess medicinal properties and are used to treat a broad range of ailments, such as respiratory-related diseases, kidney diseases, digestive diseases, diabetes, and have also been applied for healing wounds and snake bites. The phytochemical investigation revealed the presence of various types of compounds including alkaloids, phenyl propanoids, flavonoids and terpenoids of this family. The other compounds isolated from this family belong to lignans, lactones and phenolic acids. Several types of extracts and single compounds from this family have been reported to exhibit biological activities including antimicrobial, anti-inflammatory, antioxidant and cytotoxic activities. Cucurbitacin D and J (**143** and **144**, respectively) are two triterpenes that showed very strong, significant cytotoxicity against tumor cell lines BEL-7402 and SK-MEL-28.

Although a great deal of the species of this family have been discovered and identified, only a handful of species have undergone antimicrobial, anti-inflammatory and cytotoxicity studies. Of about 170 compounds identified from this family, only about 25 compounds have had its bioactivity assayed, including antibacterial, antioxidant and cytotoxicity. Up until now, no toxicity studies of both the extracts and chemical constituents of this family. Considering the interesting medicinal properties possessed by species and the chemical constituents of this family, more studies about the phytochemical and pharmacology of family Sterculiaceae are required to explore the opportunities to discover new compounds and potential medicinal and pharmacological properties and uses from this family. Furthermore, more clinical studies on the toxicity of the extracts of the plants and the compounds isolated from this family are crucially needed to ensure the safety and to assess their eligibility to be used as sources of modern medicines.

References

[1] B.A. Whitlock, C. Bayer, D.A. Baum, Phylogenetic relationships and floral evolution of the Byttnerioideae ("Sterculiaceae" or Malvaceae s.l.) based on sequences of the chloroplast gene, ndhF, Systematic Botany. 26 (2001) 420-437.

[2] P. Wilkie, A. Clark, R.T. Pennington, M. Cheek, C. Bayer, C.C. Wilcock, Phylogenetic relationships within the subfamily Sterculioideae (Malvaceae/Sterculiaceae-Sterculieae) using the chloroplast gene ndhF, Systematic Botany. 31 (2006) 160-170.

[3] H. Hsiang-hao, Sterculiaceae, Flora Reipublicae Popularis Sinicae. 49 (1984) 112-189.

[4] M.S. Alam, N. Chopra, M. Ali, M. Niwa, Oleanen and stigmasterol derivatives from *Ambroma augusta*, Phytochemistry. 41 (1996) 1197-1200.

[5] M. Martinez, Plantas Medicinales de Mexico, Ediciones Botas, Mexico, D.F., 1969.

[6] K. Kamiya, Y. Saiki, T. Hama, Y. Fujimoto, H. Endang, M. Umar, et al., Flavonoid glucuronides from *Helicteres isora*, Phytochemistry. 57 (2001) 297-301.

[7] G.Y. Dama, J.S. Bidkar, S.R. Deore, H.L. Tare, Ethnopharmacognostical survey of the plants available in the Western ghats of India, Deccan Journal of Natural Products. 1 (2010) 1-15.

[8] R.S. Bhakuni, Y.N. Shukla, R.S. Thakur, Cyclopeptide alkaloids from *Melochia corchorifolia*, Phytochemistry. 26 (1987) 324-325.

[9] Y.N. Shukla, E.A. Sokoloski, H.M. Fales, G.J. Kapadia, 6-methoxy-7,8-methylenedioxycoumaryn from *Melochia tomentosa*, Phytochemistry. 15 (1976) 1788.

[10] P. Xiao, Modern Chinese Materia Medica, Chemical Industry Press., Beijing, 2002.

[11] M.P. Correa, Dicionario das Plantas Uteis do Brasil e das Exoticas Cultivadas, Ministerio da Agricultura, Rio de Janeiro, 1931.

[12] C.M.O. Simoes, Plantas Da Medicina Popular Do Rio Grande Do Sul, Editora UFRGS, Porto Alegre, 1986.

[13] H. Lorenzi, F.J.A. Matos, Plantas Medicinais no Brasil – Nativas e Exoticas, Nova Odessa-SP, Instituto Plantarum de Estudos da Flora LTDA, 2002.

[14] G.C.D. Dias, V. Gressler, S.C.S.M. Hoenzel, U.F. Silva, I.I. Dalcol, A.F. Morel, Constituents of the roots of *Melochia chamaedrys*, Phytochemistry. 68 (2007) 668–672.

[15] R.D. Bhalke, V.S. Kasture, S.C. Pal, Separation and identification of hydrocarbons from *Pterospermum acerifolium* leaves, International Journal of Pharmacy & Pharmaceutical Sciences. 4 (2012) 158-159.

[16] P. Dixit, M.P. Khan, G. Swarnkar, N. Chattopadhyay, R. Maurya, Osteogenic constituents from *Pterospermum acerifolium* Willd. flowers, Bioorganic & Medicinal Chemistry Letters. 21 (2011) 4617-4621.

[17] A. Bouquet, Feticheurs et medecines traditionnelles du Congo Brazzaville, ORSTOM, Congo, 1969.
[18] G.J. Kapadia, Y.N. Shukla, J.F. Morton, H.A. Lloyd, New cyclopeptide alkaloids from *Melochia tomentosa*, Phytochemistry. 16 (1977) 1431-1433.
[19] A.F. Morel, I.T.S. Gehrke, M.A. Mostardeiro, E.M. Ethur, N. Zanatta, E.C.S. Machado, Cyclopeptide alkaloids from the bark of *Waltheria douradinha*, Phytochemistry. 51 (1999) 473-477.
[20] H.R. El-Seedi, S. Gohil, P. Perera, K.B.G. Torssell, L. Bohlin, Cyclopeptide alkaloids from *Heisteria nitida*, Phytochemistry. 52 (1999) 1739-1744.
[21] S.C.S.M. Hoelzel, E.R. Vieira, S.R. Giacomelli, I.I. Dalcol, N. Zanatta, A.F. Morel, An unusual quinolinone alkaloid from *Waltheria douradinha*, Phytochemistry. 66 (2005) 1163-1167.
[22] V. Gressler, C.Z. Stuker, G.O.C. Dias, I.I. Dalcol, R.A. Burrow, J. Schmidt, et al., Quinolone alkaloids from *Waltheria douradinha*, Phytochemistry. 69 (2008) 994–999.
[23] G.J. Kapadia, Y.N. Shukla, S.P. Basak, Melovinone, an open chain analogue of melochinone from *Melochia tomentosa*, Phytochemistry. 17 (1978) 1444-1445.
[24] R.S. Bhakuni, Y.N. Shukla, R.S. Thakur, Melochicorine, a pseudooxindole alkaloid from *Melochia corchorifolia*, Phytochemistry. 30 (1991) 3159-3160.
[25] R.F. Wang, X.W. Yang, C.M. Ma, M.Y. Shang, J.Y. Liang, X. Wang, et al., Alkaloids from the seeds of *Sterculia lychnophora* (Pangdahai), Phytochemistry. 63 (2003) 475-478.
[26] J.F. Hammerstone, L.J. Romanczyk, W.M. Aitken, Purine alkaloid distribution within *Herrania* and *Theobroma*, Phytochemistry. 35 (1994) 1237-1240.
[27] M.A.F. Jalal, H.A. Collin, Polyphenols of mature plant, seedling and tissue cultures of *Theobroma cacao*, Phytochemistry. 16 (1977) 1377-1380.
[28] W. Chen, W. Tang, L. Lou, W. Zhao, Pregnane, coumarin and lupane derivatives and cytotoxic constituents from *Helicteres angustifolia*, Phytochemistry. 67 (2006) 1041-1047.
[29] J.C. Vardamides, A.G.B. Azebaze, A.E. Nkengfack, F.R. Van Heerden, Z.T. Fomum, T.M. Ngando, et al., Scaphopetalone and scaphopetalumate, a lignan and a triterpene ester from *Scaphopetalum thonneri*, Phytochemistry. 62 (2003) 647-650.
[30] P. Tiew, A. Puntumchai, U. Kokpol, W. Chavasiri, Coumarins from the heartwoods of *Mansonia gagei* Drumm., Phytochemistry. 60 (2002) 773-776.
[31] R. Bruni, A. Medici, A. Guerrini, S. Scalia, F. Poli, C. Romagnoli, et al., Tocopherol, fatty acids and sterol distributions in wild Ecuadorian *Theobroma subincanum* (Sterculiaceae) seeds, Food Chemistry. 77 (2002) 337-341.
[32] T. Hatano, H. Miyatake, M. Natsume, N. Osakabe, T. Takizawa, H. Ito, et al., Proanthocyanidin glycosides and related polyphenols from cacao liquor and their antioxidant effects, Phytochemistry. 59 (2002) 749-758.
[33] L.J. Porter, Z. Ma, B.G. Chan, Cacao procyanidins: Major flavanoids and of some minor metabolites, Phytochemistry. 30 (1991) 1657-1663.
[34] J.B. Lowry, Sterculiaceae: Anthocyanins of some Malaysian *Sterculia* species, Phytochemistry. 10 (1971) 689-690.
[35] P. Tiew, H. Takayama, M. Kitajima, N. Aimi, U. Kokpola, W. Chavasiri, A novel neolignan, mansoxetane, and two new sesquiterpenes, mansonones R and S, from *Mansonia gagei*, Tetrahedron Letters. 44 (2003) 6759-6761.
[36] C.M. Chen, Z.T. Chen, Y.L. Hong, A mansonone from *Helicteres angustifolia*, Phytochemistry. 29 (1990) 980-982.
[37] R.C. Cambie, A.R. Lal, F. Ahmad, Sesquiterpenes from *Heritiera ornithocephala*, Phytochemistry. 29 (1990) 2329-2331.
[38] Y.S. Chang, Y.R. Ku, J.H. Lin, K.L. Lu, L.K. Ho, Analysis of three lupane type triterpenoids in *Helicteres angustifolia* by high-performance liquid chromatography, Journal of Pharmaceutical and Biomedical Analysis. 26 (2001) 849-855.
[39] S.A.I. Rizvi, T. Sultana, Phytochemical studies of the flowers of *Pterospermum acerifolium*, Phytochemistry. 11 (1972) 856-858.
[40] B. Wiedemann, H. Lerche, H. Lotter, A. Neszmelyi, H. Wagner, A.A. Muller, Two novel triterpenoids from the stemwood of *Herrania cuatrecasana*, Phytochemistry. 52 (1999) 333-337.
[41] A.S.R. Anjaneyulu, S.N. Raju, Cyclotriterpenes from the heartwood of *Pterospermum heyneanum*, Phytochemistry. 26 (1987) 2805-2810.
[42] X.A. Dominguez, A. Gutierrez, Sterculiaceae: Extractives from the flowers of *Chiranthodendron pentadactylon*, Phytochemistry. 11 (1972) 2895.
[43] M. Wang, W. Liu, A naphthoquinone from *Helicteres angustifolia*, Phytochemistry. 26 (1987) 578-579.
[44] D.S. Seigler, G.F. Pauli, R. Frohlich, E. Wegelius, A. Nahrstedt, K.E. Glander, et al., Cyanogenic glycosides and menisdaurin from *Guazuma ulmifolia*, *Ostrya virginiana*, *Tiquilia plicata*, and *Tiquilia canescens*, Phytochemistry. 66 (2005) 1567-1580.
[45] K.A. Reid, A.K. Jager, M.E. Light, D.A. Mulholland, J. Van Staden, Phytochemical and pharmacological screening of *Sterculiaceae* species and isolation of antibacterial compounds, Journal of Ethnopharmacology. 97 (2005) 285-291.
[46] H.M. Burkill, The Useful Plants of West Tropical Africa, Royal Botanic Gardens, Kew, 2000.
[47] H. Pittier, Manual de las Plantas Usuales de Venezuela, Fundacion Eugenio Mendoza, Caracas, 1978.
[48] J.L.C.H. van Valkenburg, N. Bunyaphrapha, Medicinal and poisonous plants 2. No. 12, Plant Resources of Southeast Asia, Backhuys Publishers, Leiden, 2001, pp. 286-288.
[49] M. Heinrich, H. Rimpler, N.A. Barrera, Indigenous phytotherapy of gastrointestinal disorders in a lowland Mixe community (Oaxaca, Mexico): Ethnopharmacologic evaluation, Journal of Ethnopharmacology. 36 (1992) 63-80.
[50] Jiangsu New Medical College, Dictionary of Chinese Herb medicines, Shanghai Scientific and Technologic Press, Shanghai, 1986.
[51] N.Y. Chiu, K.S. Chang, The Illustrated Medicinal Plants of Taiwan (I), Southern Materials Center, Inc, Taipei, 1995.
[52] S. Pongboonrod, Mai Tet Muang Thai, Karembunnakich Press, Bangkok, 1976.
[53] R.N. Chopra, S.L. Nayar, I.C. Chopra, Glossary of Indian Medicinal Plants, CSIR, New Delhi, 1956.
[54] Y. Wu, S.W. Cui, J. Wu, L. Ai, Q. Wang, J. Tang, Structure characteristics and rheological properties of acidic polysaccharide from boat-fruited sterculia seeds, Carbohydr. Polym. 88 (2012) 926-930.
[55] T.K. Lim, Edible Medicinal and Non-Medicinal Plants, Springer, Dordrecht, 2012.

[56] V. Lamxay, Important non-timber forest products of Lao PDR, in: PDR, L (Ed.), Forest Research Center, Vientiane, 2001.
[57] A.F. Morel, A. Flach, N. Zanatta, E.M. Ethur, M.A. Mostardeiro, I.T.S. Gehrke, A new cyclopeptide alkaloid from the bark of *Waltheria douradinha*, Tetrahedron Letters. 40 (1999) 9205-9209.
[58] T.L. Meragelman, K.D. Tucker, T.G. McCloud, J.H. Cardellina, R.H. Shoemaker, Antifungal flavonoids from *Hildegardia barteri*, Journal of Natural Products. 68 (2005) 1790-1792.
[59] T.M. Kenyhercz, P.T. Kissinger, Tyramine from *Theobroma cacao*, Phytochemistry. 16 (1977) 1602-1603.
[60] M. Hor, M. Heinrich, H. Rimpler, Protoanthocyanidin polymers with antisecretory activity and protoanthocyanidin oligomers from *Guazuma ulmifolia* bark, Phytochemistry. 42 (1996) 109-119.

LIST OF CAPTIONS

TABLES

FIGURES

TABLES

Table 1
Medicinal Uses of Some Sterculiaceae Species

Species	Part	Medicinal use	Reference
Ambroma augusta Linn. F.	Root	Acts as an abortifacient and antifertility agent	Alam et al. [4]
Cola cordifolia (Cav.) R Br.	Bark	Constipation and against chest-affections and dysentery, and the leaves are used as a remedy for eye-treatment	Burkill [46]
Guazuma ulmifolia Lam.	Bark	Used as a sudorific, against malaria, and a variety of other ailments. Used by the Mixe Indians of Oaxaca (Mexico) to treat diarrhea	Pittier [47]; Martinez [5]; Valkenburg and Bunyaphrapha [48], Heinrich et al. [49]
Helicteres angustifolia (L.)	Root, stem	Used as analgesic, anti-inflammatory, antibacterial agents, used to treat flu, and has been reported to show tumor growth inhibitory activity	Jiangsu New Medical College [50]; Wang and Liu [43], Chiu and Chang [51]
Helicteres isora L.	Root	Snake bites, chronic nephritis and gastric ulcers.	Dama et al. [7]
	Fruit	Used as raw material for production of "Jamu", anthelmintic against tapeworm and in treatment of gastrospasm	Kamiya et al. [6]
Herrania cuatrecasana Garcia-Barriga	Bark	Snake bite, throat irritation and dry cough	Wiedemann et al. [40]
Mansonia gagei Drumm.	*Not mentioned*	Used as cardiac stimulant, onilivertigo, antiemitic, anti-depressant and refreshment agent	Pongboonrod [52]
Melochia chamaedris A. St.Hil.	Whole plant	Cancer and as an anti-hypertensive agent	Dias et al. [14]
Melochia corcholifolia	*Not mentioned*	A decoction of the plant has been reported in folk medicines as a cure for abdominal swelling, dysentery and water snake bites	Bhakuni et al. [8]
Melochia tomentosa	Leaf, root	A decoction of leaves or roots is recommended for the relief of throat inflammation in Curacao. During a diphtheria epidemic, a decoction of roots of this plant combined with other plants was used	Shukla et al. [9]
Pterospermum acerifolium (L.) Willd	Flower	Used as a general tonic, anti-tumor agent, analgesic and for the treatment of diabetes, gastrointestinal disorders, leprosy, blood troubles, bronchitis, cough, cephalic pain, migraine and inflammation	Bhalke et al. [15]
	Bark	Diabetes	Dixit et al. [16]
Pterospermum heyneanum Wall.	Leaf	Leuchorrhoea	Chopra et al. [53]
Scaphopetalum thonneri	Bark	Kidney disease, wounds and stomach-ache	Bouquet [17]
Semen Sterculiae Lychnophorae	*Not mentioned*	Clearing phlegm (by "clearing heat from the lungs" as explained in Chinese medicine) and relieving sore throat to restore the voice on the upper respiratory tract, relaxing the bowels to relieve constipation	Xiao [10], Wu et al. [54]
Sterculia lychnophora Hance	Seed	Pharyngitis, tussis and constipation	Wang et al. [25]
Waltheria douradinha St Hil.	Whole plant	Respiratory disorders, as a stimulant, emetic, and diuretic, urinary diseases and, externally, as a wound cleansing and healing agent	Correa [11]; Simoes [12]; Lorenzi and Matos [13]
Scaphium macropodum	Seed	Used to treat intestinal infections, diarrhoea, throat aches, asthma, dysentery, fever, coughs, inflammation, urinary illness, pharyngitis, tussis and constipation	Lim [55]; Lamxay [56]

Table 2
Alkaloids from Sterculiaceae Species

No	Compound name	Source (Plant part)	Reference
1	Chamaedrine	*Melochia chamaedrys* (root)	Dias et al. [14]
2	Adouetine X	*Melochia chamaedrys* (root)	Dias et al. [14]
3	Frangufoline	*Melochia chamaedrys* (root), *Melochia corchorifolia* (leaf)	Dias et al. [14]; Bhakuni et al. [8]
4	Scutianine B	*Melochia chamaedrys* (root), *Melochia tomentosa* (root), *Waltheria douradinha* (bark)	Dias et al. [14]; Kapadia et al. [18]; Morel et al. [19]
5	Scutianine C	*Melochia chamaedrys* (root)	Dias et al. [14]
6	Melanovine A	*Melochia tomentosa* (root)	Kapadia et al. [18]
7	Melanovine B	*Melochia tomentosa* (root)	Kapadia et al. [18]
8	Waltherine A	*Waltheria douradinha* (bark)	Morel et al. [19]
9	Waltherine B	*Waltheria douradinha* (bark)	Morel et al. [19]
10	Waltherine C	*Waltheria douradinha* (bark)	Morel et al. [57]
11	Adouetine Y	*Waltheria douradinha* (bark), *Melochia corchorifolia* (leaf)	Morel et al. [19]; Bhakuni et al. [8]
12	Franganine	*Melochia corchorifolia* (leaf)	Bhakuni et al. [8]; Bhakuni et al. [24]
13	Melofoline	*Melochia corchorifolia* (leaf)	Bhakuni et al. [8]
14	Integerrenine	*Heisteria nitida* (bark)	El-Seedi et al. [20]
15	Anorldianine 27-N oxide	*Heisteria nitida* (bark)	El-Seedi et al. [20]
16	Waltherione A	*Melochia chamaedrys* (root), *Waltheria douradinha* (bark)	Dias et al. [14]; Hoelzel et al. [21]; Gressler et al. [22]
17	Waltherione B	*Waltheria douradinha* (stem)	Gressler et al. [22]
18	Melochinone	*Melochia tomentosa* (root)	Kapadia et al. [23]
19	Melovinone	*Melochia tomentosa* (root)	Kapadia et al. [23]
20	Melosatin A	*Melochia tomentosa* (root)	Kapadia et al. [23]
21	Melosatin B	*Melochia tomentosa* (root)	Kapadia et al. [23]
22	Vanessine	*Waltheria douradinha* (stem)	Gressler et al. [22]
23	Antidesmone	*Waltheria douradinha* (stem)	Gressler et al. [22]
24	Sterculinine I	*Sterculia lychnophora* Hance (seed)	Wang et al. [25]
25	Sterculinine II	*Sterculia lychnophora* Hance (seed)	Wang et al. [25]
26	Melochicorine	*Melochia corchorifolia* (leaf)	Bhakuni et al. [24]
27	*O*-methyltembamide	*Waltheria douradinha* (stem)	Gressler et al. [22]
28	Caffeine	*Theobroma bicolor, T. speciosum, T. angustifolium, T. grandiflorum, T. simiarum, T. mammosum, T. cacao, Herrania albiflora, H. balaensis, H. cuatrecasana, H. nitida, H. purpurea*	Hammerstone et al. [26]
29	Theobromine	*T. bicolor, T. mammosum, T. cacao, T. grandiflorum*	Hammerstone et al. [26]
30	Theacrine	*T. speciosum, T. bicolor, T. mammosum, T. speciosum, T. microcarpum, T. angustifolium, T. grandiflorum, T. subincanum, T. H. albiflora, H. balaensis, H. cuatrecasana, H. nitida, H. purpurea, H. columbias, H. mariae, H. nycteroodendron, H. umbratica*	Hammerstone et al. [26]
31	Uracil	*Sterculia lychnophora* Hance (seed)	Wang et al. [25]
32	Adenosine	*Sterculia lychnophora* Hance (seed)	Wang et al. [25]

Table 3
Phenyl Propanoids from Sterculiaceae Species

No	Compound name	Source (Plant Part)	Reference
33	*p*-coumaric acid	*Theobroma cacao* (leaf), *Pterospermum acerifolium* Willd. (flower)	Jalal and Collin [27]; Dixit et al. [16]
34	Caffeic acid	*T. cacao* (leaf)	Jalal and Collin [27]
35	Coniferol	*H. angustifolia* (leaf)	Chen et al. [28]
36	3-(3,4-dimethoxyphenyl)-2-propenal	*H. angustifolia* (leaf)	Chen et al. [28]
37	*p*-coumaroylquinic acid	*T. cacao* (leaf)	Jalal and Collin [27]
38	Chlorogenic acid	*T. cacao* (leaf)	Jalal and Collin [27]
39	Scopolin	*Scaphopetalum thonneri* (heartwood)	Vardamides et al. [29]
40	Scopoletin	*S. thonneri* (heartwood)	Vardamides et al. [29]
41	Mansonrin A	*Mansonia gagei* (heartwood)	Tiew et al. [30], Tiew et al. [35]
42	Mansonrin B	*M. gagei* (heartwood)	Tiew et al. [30]
43	Mansonrin C	*M. gagei* (heartwood)	Tiew et al. [30], Tiew et al. [35]
44	6-methoxy-7,8-methylenedioxycoumarin	*Melochia tomentosa* (root)	Shukla et al. [9]

45	6-hydroxy-3,4,-dihydro-4,7-dimethylbenzo-1-pyran-2-one	*Heritiera ornithocephala* (heartwood)	Cambie et al., 1990
46	6,7,9α-trihydroxy-3,8,11α-trimethylcyclohexo-[δ,ε]-coumarin	*H. angustifolia* (root)	Chen et al. [28]
47	Propacine	*Melochia chamaedrys* (root)	Dias et al. [14]
48	α-tocopherol	*T. subincanum* (seed)	Bruni et al. [31]
49	β-tocopherol	*T. subincanum* (seed)	Bruni et al. [31]
50	γ-tocopherol	*T. subincanum* (seed)	Bruni et al. [31]
51	δ-tocopherol	*T. subincanum* (seed)	Bruni et al. [31]

Table 4
Flavonoids from Sterculiaceae Species

No	Compound name	Type	Source (Plant part)	Reference
52	Apigenin	Flavone	*Pterospermum acerifolium* Willd. (flower)	Dixit et al. [16]
53	3'-methoxy-apigenin	Flavone	*P.acerifolium* Willd. (flower)	Dixit et al. [16]
54	Apigenin 7-*O*-glucoside = Apigetrin	Flavone glycoside	*Theobroma cacao* L. (leaf)	Jalal and Collin [27]
55	Apigenin-7-β-*O*-neohesperidoside	Flavone glycoside	*P.acerifolium* Willd. (flower)	Dixit et al. [16]
56	Luteolin	Flavone	*P.acerifolium* Willd. (flower)	Dixit et al. [16]
57	Luteolin 7-*O*-glucoside (Cynaroside)	Flavone glycoside	*T. cacao* (leaf), *P.acerifolium* Willd. (flower)	Dixit et al. [16], Jalal and Collin [27]
58	Luteolin-7-β-*O*-neohesperidoside	Flavone glycoside	*P.acerifolium* Willd. (flower)	Dixit et al. [16]
59	5,8-dihydroxy-7,4'-dimethoxyflavone	Flavone	*Helicteres angustifolia* (root)	Chen et al. [28]
60	Quercetin 3-*O*-glucoside	Flavone glycoside	*T. cacao* L. (leaf)	Jalal and Collin [27]
61	Quercetin 3-*O*-galactoside	Flavone glycoside	*T. cacao* L. (leaf)	Jalal and Collin [27]
62	Quercetin 3-*O*-α-L-arabinopyranosyde	Flavone glycoside	*T. cacao* L. (leaf)	Hatano et al. [32]
63	Kaempferol-3-*O*-β-ᴅ-glucoside	Flavone glycoside	*Sterculia lychnophora* Hance (seed), *H. angustifolia* (root)	Wang et al. [25]; Chen et al. [28]
64	Kaempferol- 3-*O*-β-ᴅ-rutinoside	Flavone glycoside	*S. lychnophora* Hance (seed)	Wang et al. [25]
65	Vitexin	Flavone glycoside	*P.acerifolium* Willd. (flower); *T. cacao* L. (leaf)	Dixit et al. [16], Jalal and Collin [27]
66	Isovitexin	Flavone glycoside	*T. cacao* L. (leaf)	Jalal and Collin [27]
67	Chryseriol 7-*O*-glucoside	Flavone glycoside	*T. cacao* L. (leaf)	Jalal and Collin [27]
68	Isorhamnetin-3-*O*-β-ᴅ-rutinoside	Flavone glycoside	*S. lychnophora* Hance (seed)	Wang et al. [25]
69	8-*O*-β-ᴅ-glucuronyl-hypolaetin 4'-methyl ether	Flavone glycoside	*H. angustifolia* (root)	Chen et al. [28]
70	Pterospermin B	Flavone glycoside	*P.acerifolium* Willd. (flower)	Dixit et al. [16]
71	Isoscutellarein 4'-methyl ether 8-*O*-β-ᴅ-glucuronide	Flavone glycoside	*Helicteres isora* (fruit)	Kamiya et al. [6]
72	Isoscutellarein 4'-methyl ether 8-*O*-β-ᴅ-glucuronide 6"-*n*-butyl ester	Flavone glycoside	*H. isora* (fruit)	Kamiya et al. [6]
73	Isoscutellarein 4'-methyl ether 8-*O*-β-ᴅ-glucuronide 2",4"-disulfate	Flavone glycoside	*H. isora* (fruit)	Kamiya et al. [6]
74	Isoscutellarein 8-*O*-β-ᴅ-glucuronide 2",4"-disulfate	Flavone glycoside	*H. isora* (fruit)	Kamiya et al. [6]
75	Isoscutellarein 4'-methyl ether 8-*O*-β-ᴅ-glucuronide 2"-sulfate	Flavone glycoside	*H. isora* (fruit)	Kamiya et al. [6]
76	Pterospermin A	Flavone	*P.acerifolium* Willd. (flower)	Dixit et al. [16]
77	*Trans*-tiliroside	Flavone glycoside	*P.acerifolium* Willd. (flower)	Dixit et al. [16]
78	(+)-catechin	Flavan	*T. cacao* L. (leaf/bean), *Heisteria nitida* (bark)	Jalal and Collin [27]; Hatano et al. [32]; El-Seedi et al. [20]
79	(-)-epicatechin	Flavan	*T. cacao* L. (leaf/bean), *Melochia chamaedrys* (root)	Jalal and Collin [27]; Hatano et al. [32]; El-Seedi et al. [20]
80	(-)-epicathecin 8-*C*-β-ᴅ-galactoside	Flavan glycoside	*T. cacao* L. (leaf)	Hatano et al. [32]
81	Leucocyanidin	Flavan	*T. cacao* L. (leaf)	Jalal and Collin [27]
82	Hildegardiol	Isoflavan	*Hildegardia barteri*	Meragelman et al. [58]
83	2-hydroxymaackiain	Isoflavan	*Hildegardia barteri*	Meragelman et al. [58]
84	Procyanidin A1	Dimer flavan	*T. cacao* L. (bean)	Hatano et al. [32]
85	Procyanidin A2	Dimer flavan	*T. cacao* L. (bean)	Porter et al. [33]; Hatano et al. [32]
86	Procyanidin B1	Dimer flavan	*T. cacao* L. (bean)	Porter et al., 1991
87	Procyanidin B2	Dimer flavan	*T. cacao* L. (bean)	Porter et al. [33]; Hatano et al. [32]
88	Procyanidin B5	Dimer flavan	*T. cacao* L. (bean)	Hatano et al., 2002
89	Mahuaninn A	Dimer flavan	*T. cacao* L. (bean)	Porter et al. [33]

90	Mahuaninn B	Dimer flavan	*T. cacao* L. (bean)	Porter et al. [33]
91	Mahuaninn C	Dimer flavan	*T. cacao* L. (bean)	Porter et al. [33]
92	Epicatechin-(4β→6)-epicatechin	Dimer flavan	*T. cacao* L. (bean)	Porter et al. [33]
93	Epicatechin-(2β→5,4β→6)-epicatechin	Dimer flavan	*T. cacao* L. (bean)	Porter et al. [33]
94	Epicatechin-(2β→7,4β→6)-epicatechin	Dimer flavan	*T. cacao* L. (bean)	Porter et al. [33]
95	Bis-8,8'-catechinylmethane	Dimer flavan	*T. cacao* L. (bean)	Hatano et al. [32]
96	Procyanidin C1	Trimer flavan	*T. cacao* L. (bean)	Porter et al. [33]; Hatano et al. [32]
97	Cinnamtannin A2 = [Epicathechin-(4β→8)]$_3$-epicathechin	Tetramer flavan	*T. cacao* L. (bean)	Porter et al. [33]; Hatano et al. [32]
98	3-*T*-*O*-arabinopyranosyl-*ent*-epicathecin-(2α→7, 4α→8)-catechin	Dimer flavan glycoside	*T. cacao* L. (bean)	Hatano et al. [32]
99	3-*O*-β-ᴅ-galactopyranosyl ent-epicatechin-(2α→7,4α→8)-epicathechin	Dimer flavan glycoside	*T. cacao* L. (bean)	Porter et al. [33]; Hatano et al. [32]
100	3-*O*-L-arabinopyranosyl ent-epicatechin-(2α→7,4α→8)-epicathechin	Dimer flavan glycoside	*T. cacao* L. (bean)	Porter et al. [33]; Hatano et al. [32]
101	3-T-*O*-galactopyranosyl cinnamtannin B1	Trimer flavan glycoside	*T. cacao* L. (bean)	Hatano et al. [32]
102	3-T-*O*-arabinopyranosyl cinnamtannin B1	Trimer flavan glycoside	*T. cacao* L. (bean)	Hatano et al. [32]
103	Cyanidin-3-galactoside	Anthocyanidin	*T. cacao* L. (leaf)	Lowry [34]; Jalal and Collin [27]
104	Cyanidin-3-arabinoside	Anthocyanidin	*T. cacao* L. (leaf)	Lowry [34]; Jalal and Collin [27]

Table 5
Terpenoids from Sterculiaceae Species

No	Compound	Type	Source (Plant Part)	Reference
105	(6*R*,9*S*)-3-oxo-α-ionol-β-D-glucopyranoside	Monoterpene glycoside	*Pterospermum acerifolium* Willd. (flower)	Dixit et al. [16]
106	Linalool-3-rutinoside	Monoterpene glycoside	*P. acerifolium* Willd. (flower)	Dixit et al. [16]
107	Mansonone C	Sesquiterpene	*Mansonia gagei* (heartwood)	Tiew et al. [30], Tiew et al. [35]
108	Mansonone E	Sesquiterpene	*Helicteres angustifolia, M. gagei* (heartwood)	Chen et al. [28], Chen et al. [36]; Tiew et al. [35]
109	Mansonone F	Sesquiterpene	*H. angustifolia* (root bark)	Chen et al. [28], Chen et al. [36]
110	Mansonone G	Sesquiterpene	*M. gagei* (heartwood)	Tiew et al. [30], Tiew et al. [35]
111	Mansonone H	Sesquiterpene	*H. angustifolia* (root bark), *M. gagei* (heartwood)	Chen et al. [28], Chen et al. [36]; Tiew et al. [30], Tiew et al. [35]
112	Mansonone H methyl ester	Sesquiterpene	*H. angustifolia* (root bark)	Chen et al. [28]
113	Mansonone M	Sesquiterpene	*H. angustifolia* (root bark)	Chen et al. [28]
114	Mansonone R	Sesquiterpene	*M. gagei* (heartwood)	Tiew et al. [35]
115	Mansonone S	Sesquiterpene	*M. gagei* (heartwood)	Tiew et al. [30]
116	7-hydroxycalamenene	Sesquiterpene	*Heritiera ornithocephala* (heartwood)	Cambie et al. [37]
117	8-hydroxy-2,3,4,5-tetrahydro-2,7,11,11-tetramethyl-1-benzox-epin-4-one	Sesquiterpene	*H. ornithocephala* (heartwood)	Cambie et al. [37]
118	8-bis(7-hydroxycalamenene)	Dimer sesquiterpene	*H. ornithocephala* (heartwood)	Cambie et al. [37]
119	2α,7β,20α-trihydroxy-3β,21-dimethoxy-5-pregnene	Diterpene	*H. angustifolia* (root)	Chen et al. [28]
120	Squalene	Triterpene	*Theobroma subincanum*	Bruni et al., 2002
121	Lupeol	Triterpene	*Heritiera utilis, Heisteria nitida* (bark)	Blair et al., 1970; El Seedi et al., 1999
122	3β-acetoxylup-20(29)-en-28-ol	Triterpene	*H. angustifolia* (root)	Chen et al. [28]
123	Betulinic acid	Triterpene	*H. angustifolia* (root)	Chen et al. [28]
124	3β-hydroxylup-20(29)-en-28-oic acid 3-caffeate	Triterpene	*H. angustifolia* (root)	Chen et al. [28]
125	Helicteric acid	Triterpene	*H. angustifolia* (root)	Chen et al. [28]
126	Methyl helicterate	Triterpene	*H. angustifolia* (root and stem)	Chang et al. [38]; Chen et al. [28]
127	3β-acetoxyl-27-(*p*-hydroxyl)benzoyloxylup-20(29)-en-28-oic acid methyl ester	Triterpene	*H. angustifolia* (root and stem)	Chang et al. [38]; Chen et al. [28]
128	3β-hydroxy-27-benzoyloxylup-20(29)-en-28-oic acid methyl ester	Triterpene	*H. angustifolia* (root)	Chen et al. [28]
129	Friedelan-3α-ol	Triterpene	*P. acerifolium* Willd. (flower)	Rizvi and Sultana [39]
130	Friedelan-3β-ol	Triterpene	*P. acerifolium* Willd. (flower)	Rizvi and Sultana [39]
131	β-amyrin	Triterpene	*P. acerifolium* Willd. (flower)	Rizvi and Sultana [39]
132	Oleanolic acid	Triterpene	*H. angustifolia* (whole plants), *Scaphopetalum thonneri* (bark)	Chen et al. [28]; Vardamides et al. [29]
133	Scaphopetalumate	Triterpene	*S. thonneri* (bark)	Vardamides et al. [29]
134	Augustic acid	Triterpene	*Ambroma augusta* (root)	Alam et al. [4]
135	Herranone	Triterpene	*Herrania cuatrecassana* (stem)	Wiedemann et al. [40]
136	Herrantrione	Triterpene	*H. cuatrecassana* (stem)	Wiedemann et al. [40]
137	Cycloartenol	Triterpene	*T. subincanum* (seed)	Bruni et al. [31]
138	24-methylene cycloartenol	Triterpene	*T. subincanum* (seed)	Bruni et al. [31]
139	Δ^5-avenosterol	Triterpene	*T. subincanum* (seed)	Bruni et al. [31]
140	Cyclopterospermol	Triterpene	*Pterospermum heyneanum* (stem)	Anjaneyulu and Raju [41]
141	30-norcyclopterospermol	Triterpene	*P. heyneanum* (stem)	Anjaneyulu and Raju [41]
142	30-norcyclopterospermone	Triterpene	*P. heyneanum* (stem)	Anjaneyulu and Raju [41]
143	Cucurbitacin D	Triterpene	*H. angustifolia* (root)	Chen et al. [28]
144	Cucurbitacin J	Triterpene	*H. angustifolia* (root)	Chen et al. [28]

145	β-sitosterol	Steroid	*H. angustifolia* (root), *Sterculia lychnophora* Hance (seed), *Heisteria nitida* (bark)	Chen et al. [28]; Wang et al. [25]; El-Seedi et al. [20]
146	Acetate sitosterol	Steroid	*Chiranthodendron pentadactylon* (flower)	Dominguez and Gutierrez [42]
147	Stigmasterol	Steroid	*H. nitida* (bark)	El-Seedi et al. [20]
148	Stigmasterol glucoside= Daucosterol	Steroid	*Ambroma augusta* (root), *S. lychnophora* Hance (seed)	Alam et al. [4]; Wang et al. [25]
149	Campesterol	Steroid	*T. subincanum* (seed)	Bruni et al. [31]

Table 6
Miscellaneous Compounds from Sterculiaceae Species

No	Compound	Type	Source (Plant part)	Reference
150	1-undecene	Alkene	*Pterospermum acerifolium* Willd. (flower)	Dixit et al. [16]
151	1-octacosene	Alkene	*Chiranthodendron pentadactylon* (flower)	Dominguez and Gutierrez [42]
152	*n*-docosanol	Alcohol	*C. pentadactylon* (flower)	Dominguez and Gutierrez [42]
153	*n*-octacosanol	Alcohol	*Pterospermum heyneanum* (stem)	Anjaneyulu and Raju [41]
154	Tyramine	Monoamine	*Theobroma cacao*L. (seed)	Kenyhercz and Kissinger [59]
155	*n*-butyl-α-ᴅ-mannopyranoside	Sugar	*Sterculia lychnophora* Hance (seed)	Wang et al. [25]
156	Sucrose	Sugar	*S. lychnophora* Hance (seed)	Wang et al. [25]
157	3-hydroxy-5-methoxy-2-methylbenzoquinone	Quinone	*P. heyneanum* (stem)	Anjaneyulu and Raju [41]
158	Heliquinone	Naphtoquinone	*Helicteres angustifolia* (root)	Wang and Liu [43]
159	Succinic acid	Carboxylic acid	*S. lychnophora* Hance (seed)	Wang et al. [25]
160	4-hydroxy-2-methoxy benzoic acid	Phenolic acid	*Heisteria nitida* (bark)	El-Seedi et al. [20]
161	Vanillic acid	Phenolic acid	*P. acerifolium* Willd. (flower)	Dixit et al. [16]
162	Protocathecuic acid	Phenolic acid	*T. cacao* L. (bean)	Hatano et al. [32]
163	2,4-dihidroxy benzoic acid	Phenolic acid	*S. lychnophora* Hance (seed)	Wang et al. [25]
164	Parasorbic acid	Lactone (ester)	*Melochia chamaedrys* (root)	Dias et al. [14]
165	3,5-dihidroxyfuran-2(5H)-one (pterospermin C)	Lactone (ester)	*P. acerifolium* Willd. (flower)	Dixit et al. [16]
166	(3*R*,4*R*,5*S*)-3,4-dihydroxy-5-methyl-dihydrofuran-2-one	Lactone (ester)	*P. acerifolium* Willd. (flower)	Dixit et al. [16]
167	Rosmarinic acid	Lignan	*H. angustifolia* (root)	Chen et al. [28]
168	Lariciresinol	Lignan	*H. angustifolia* (root)	Chen et al. [28]
169	(+)-pinoresinol	Lignan	*H. angustifolia* (root)	Chen et al. [28]
170	Lirioresinol-B	Lignan	*H. angustifolia* (root)	Chen et al. [28]
171	Scaphopetalone	Lignan	*Scaphopetalum thonneri* (bark)	Vardamides et al. [29]
172	Mansoxetane	Lignan	*Mansonia gagei* (stem)	Tiew et al. [35]
173	(2*R*)-taxiphyllin	Cyanogenic glycoside	*Guazuma ulmifolia* (leaf)	Seigler et al. [44]
174	(2*S*)-dhurrin	Cyanogenic glycoside	*G. ulmifolia* (leaf)	Seigler et al. [44]
175	Soya-cerebroside II	Amide	*S. lychnophora* Hance (seed)	Wang et al. [25]
176	1-*O*-β-ᴅ-glucopyranosyl-(2*S*,3*R*,4*E*,8*Z*)-2-[(2-hydroxy-icosanoyl)amido]-4,8-octadecadiene-1,3-diol	Amide	*S. lychnophora* Hance (seed)	Wang et al. [25]

Table 7
Biological Activities of Some Sterculiaceae Species

Biological activity	Species	Extract	Description	Reference
Antibacterial	*Cola greenwayi*	Leaf	Ethyl acetate extract showed moderate activity against *Klebsiella pneumoniae* (MIC ≤ 0.78 mg/ml) and *Staphylococcus aureus* (MIC ≤ 0.39 mg/ml). Standard used was Neomycin with MIC of 3.1×10^{-2} and 6.25×10^{-2} mg/mL against *K. pneumoniae* and *S. aureus*, respectively.	Reid et al. [45]
	Cola natalensis	Leaf	No antibacterial activity against *Bacillus subtilis, S. aureus, Escherichia coli, K. pneumoniae*	Reid et al. [45]
	Dombeya cymosa	Leaf	Ethanolic extract gave MIC values of 0.195 and 0.78 mg/ml against *S. aureus* and *K. pneumoniae*. Standard used was Neomycin with MIC of 6.25×10^{-2} and 3.1×10^{-2} mg/mL against *S. aureus* and *K. pneumoniae*, respectively.	Reid et al. [45]
	Dombeya burgessiae	Leaf	No antibacterial activity against *B. subtilis, S. aureus, E. coli, K. pneumoniae*	Reid et al. [45]
	Hermannia depressa	Root	Ethanolic extract gave MIC values of 0.195 mg/ml against *B. subtilis*. Standard used was Neomycin with MIC of 1.56×10^{-2} mg/mL.	Reid et al. [45]
	Guazuma ulmifolia	Bark	The ethanolic extract of the bark (C) inhibits cholera toxin-induced secretion in rabbit distal colon mounted in an Ussing chamber.	Hor et al. [60]
Anti-inflammatory	*C. greenwayi*	Leaf, twigs	Ethanolic extracts of leaf and twigs both exhibited good COX-1 inhibition activity (75% and 78%, respectively). Dicholoromethane extract of twigs also showed good activity (78%).	Reid et al. [45]
	C. natalensis	Leaf	Showed low levels of inhibition against COX-1.	Reid et al. [45]
	D. burgessiae	Leaf, twigs	High activity was obtained in both the ethanolic (76% and 89%) and dichloromethane (81% and 87%) extracts from the leaf and twig material, respectively.	Reid et al. [45]
	D. cymosa	Leaf, twigs	Exhibited high activity in the ethanol extracts of the leaf (78%) and twig (84%).	Reid et al. [45]
	H. depressa	Stem, root	Dichloromethane extract of stem and root displayed high activity (78% and 81%, respectively).	Reid et al. [45]
Cytotoxicity	*Mansonia gagei*	Heart-wood	Hexane and dichloromethane extracts exhibited cytotoxicity against brine shrimp *Artemia salina* Linn. With LC50 of 23.69 and 22.83 μg/ml, respectively.	Tiew et al. [30]

Table 8
Biological Activities of Some Compounds from Sterculiaceae Species

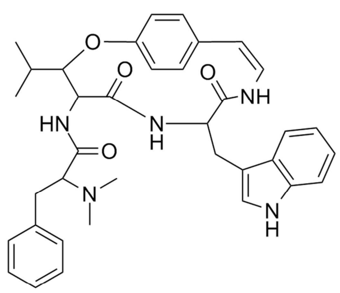
No	Compound name	Biological activity	Description	Reference
6	Waltherione A	Antimicrobial	Inactive against *Staphylococcus aureus* (ATCC 6538p), *Staphylococcus epidermidis* (ATCC 12228), *Micrococcus luteus* (ATCC 9341), and three Gram-Negative bacteria: *Klebsiela pneumoniae* (ATCC 10031), *Salmonella setubal* (ATCC 19196) and *Escherichia coli* (ATCC 11103). Amoxillin was used as positive control.	Hoelzel et al. [21]
7	Waltherione B	Anti-microbial	Inactive against three Gram-positive bacteria: *S. aureus* (ATCC 6538p), *S. epidermidis* (ATCC 12228), *Bacillus subtilis* (ATCC 6633), four Gram-negative bacteria: *K. pneumoniae* (ATCC 10031), *E. coli* (ATCC 11103) *Staphylococcus setubal* (ATCC 19196) and *Pseudomona aeruginosa* (ATCC 9341), and three yeasts: *Saccharomyces cerevise* (ATCC 2601), *Candida albicans* (ATCC 10231) and *Cryptococcus neoformans* (ATCC 289).	Gressler et al. [22]
8	Vanessine	Anti-microbial	Exhibited very low activity against *E. coli*, *Staphylococcus setubal* and *K. pneumoniae*, with MIC of 25.0, 50.0, 25.0 µg/mL, respectively. Chloramphenicol was used as positive standard, MIC against the three strains were 3.12, 3.12, and 1.56 µg/mL, respectively).	Gressler et al. [22]
9	Antidesmone	Anti-microbial	Inactive against three Gram-positive bacteria: *S. aureus* (ATCC 6538p), *S. epidermidis* (ATCC 12228), *Bacillus subtilis* (ATCC 6633), four Gram-negative bacteria: *K. pneumoniae* (ATCC 10031), *E. coli* (ATCC 11103) *Staphylococcus setubal* (ATCC 19196) and *Pseudomona aeruginosa* (ATCC 9341), and three yeasts: *Saccharomyces cerevise* (ATCC 2601), *Candida albicans* (ATCC 10231) and *Cryptococcus neoformans* (ATCC 289).	Gressler et al. [22]
10	*O*-methyltembamide	Anti-microbial	Inactive against three Gram-positive bacteria: *S. aureus*, *S. epidermidis*, *Bacillus subtilis*, four Gram-negative bacteria: *K. pneumoniae*, *E. coli, Staphylococcus setubal* (ATCC 19196) and *Pseudomona aeruginosa* (ATCC 9341), and three yeasts: *Saccharomyces cerevise*, *Candida albicans* and *Cryptococcus neoformans*.	Gressler et al. [22]
41	Mansonrin A	Cytotoxicity	Exhibited medium cytotoxicity against brine shrimp *Artemia salina* Linn. With LC_{50} of 24.18 µg/mL. DMSO was used as standard.	Tiew et al. [30]
42	Mansonrin B	Cytotoxicity	Exhibited high cytotoxicity against brine shrimp *Artemia salina* Linn. With LC_{50} of 0.61 µg/mL. DMSO was used as standard.	Tiew et al. [30]
43	Mansonrin C	Cytotoxicity	Exhibited low cytotoxicity against brine shrimp *Artemia salina* Linn. With LC_{50} of 187.85 µg/mL. DMSO was used as standard.	Tiew et al. [30]
79	(-)-epicatechin	Antioxidant	Inhibited NADPH-dependent lipid peroxidation in rat liver microsomes with IC_{50} of 29 µg/mL. Control used was dl-a-tocopherol with IC_{50} of 5.6 µg/mL.	Hatano et al. [32]
			Exhibited higher antioxidant activity in inhibiting the autooxidation of linoleic acid (IC_{50} of 0.62 µg/mL) compared to control (dl-a-tocopherol with IC_{50} of 7.7 µg/mL).	Hatano et al. [32]
			Displayed higher radical scavenging activity on DPPH radical (IC_{50} of 0.62 µg/mL) compared to control (dl-a-tocopherol with IC_{50} of 4.6 µg/mL).	Hatano et al. [32]
80	(-)-epicathecin 8-*C*-β-ᴅ-galactoside	Antioxidant	Showed no inhibition activity on NADPH-dependent lipid peroxidation in rat liver microsomes with IC_{50} of > 100 µg/mL. Control used was dl-a-tocopherol with IC_{50} of 5.6 µg/mL.	Hatano et al. [32]
			Exhibited higher antioxidant activity in inhibiting the autooxidation of linoleic acid (IC_{50} of 9.5 µg/mL) compared to control (dl-a-tocopherol with IC_{50} of 7.7 µg/mL).	Hatano et al. [32]
			Displayed higher radical scavenging activity on DPPH radical (IC_{50} of 3.9 µg/mL) compared to control (dl-a-tocopherol with IC_{50} of 4.6 µg/mL).	Hatano et al. [32]
87	Procyanidin B2	Antioxidant	Inhibited NADPH-dependent lipid peroxidation in rat liver microsomes with IC_{50} of 12 µg/mL. Control used was dl-a-tocopherol with IC_{50} of 5.6 µg/mL.	Hatano et al. [32]

			Displayed higher radical scavenging activity on DPPH radical (IC_{50} of 1.4 μg/mL) compared to control (dl-a-tocopherol with IC_{50} of 4.6 μg/mL).	Hatano et al. [32]
88	Procyanidin B5	Antioxidant	Inhibited NADPH-dependent lipid peroxidation in rat liver microsomes with IC_{50} of 12 μg/mL. Control used was dl-a-tocopherol with IC_{50} of 5.6 μg/mL.	Hatano et al. [32]
			Exhibited higher antioxidant activity in inhibiting the autooxidation of linoleic acid (IC_{50} of 2.3 μg/mL) compared to control (dl-a-tocopherol with IC_{50} of 7.7 μg/mL).	Hatano et al. [32]
			Displayed higher radical scavenging activity on DPPH radical (IC_{50} of 2.3 μg/mL) compared to control (dl-a-tocopherol with IC_{50} of 4.6 μg/mL).	Hatano et al. [32]
96	Procyanidin C1	Antioxidant	Inhibited NADPH-dependent lipid peroxidation in rat liver microsomes with IC_{50} of 68 μg/mL. Control used was dl-a-tocopherol with IC_{50} of 5.6 μg/mL.	Hatano et al. [32]
			Exhibited higher antioxidant activity in inhibiting the autooxidation of linoleic acid (IC_{50} of 5.3 μg/mL) compared to control (dl-a-tocopherol with IC_{50} of 7.7 μg/mL).	Hatano et al. [32]
			Displayed lower radical scavenging activity on DPPH radical (IC_{50} of 6.2 μg/mL) compared to control (dl-a-tocopherol with IC_{50} of 4.6 μg/mL).	Hatano et al. [32]
97	Cinnamtannin A2	Antioxidant	Inhibited NADPH-dependent lipid peroxidation in rat liver microsomes with IC_{50} of 25 μg/mL. Control used was dl-a-tocopherol with IC_{50} of 5.6 μg/mL.	Hatano et al. [32]
			Exhibited higher antioxidant activity in inhibiting the autooxidation of linoleic acid (IC_{50} of 2.7 μg/mL) compared to control (dl-a-tocopherol with IC_{50} of 7.7 μg/mL).	Hatano et al. [32]
			Displayed higher radical scavenging activity on DPPH radical (IC_{50} of 2.1 μg/mL) compared to control (dl-a-tocopherol with IC_{50} of 4.6 μg/mL).	Hatano et al. [32]
99	3-*O*-β-ᴅ-galactopyranosyl ent-epicatechin-(2α→7,4α→8)-epicathechin	Antioxidant	Inhibited NADPH-dependent lipid peroxidation in rat liver microsomes with IC_{50} of 18 μg/mL. Control used was dl-a-tocopherol with IC_{50} of 5.6 μg/mL.	Hatano et al. [32]
			Exhibited higher antioxidant activity in inhibiting the autooxidation of linoleic acid (IC_{50} of 2.5 μg/mL) compared to control (dl-a-tocopherol with IC_{50} of 7.7 μg/mL).	Hatano et al. [32]
			Displayed higher radical scavenging activity on DPPH radical (IC_{50} of 3.9 μg/mL) compared to control (dl-a-tocopherol with IC_{50} of 4.6 μg/mL).	Hatano et al. [32]
100	3-*O*-L-arabinopyranosyl ent-epicatechin-(2α→7,4α→8)-epicathechin	Antioxidant	Inhibited NADPH-dependent lipid peroxidation in rat liver microsomes with IC_{50} of 21 μg/mL. Control used was dl-a-tocopherol with IC_{50} of 5.6 μg/mL.	Hatano et al. [32]
			Exhibited higher antioxidant activity in inhibiting the autooxidation of linoleic acid (IC50 of 2.2 μg/mL) compared to control (dl-a-tocopherol with IC_{50} of 7.7 μg/mL).	Hatano et al. [32]
			Displayed higher radical scavenging activity on DPPH radical (IC50 of 3.9 μg/mL) compared to control (dl-a-tocopherol with IC_{50} of 4.6 μg/mL).	Hatano et al. [32]
101	3-T-*O*-galactopyranosyl cinnamtannin B1	Antioxidant	Inhibited NADPH-dependent lipid peroxidation in rat liver microsomes with IC_{50} of 36 μg/mL. Control used was dl-a-tocopherol with IC_{50} of 5.6 μg/mL.	Hatano et al. [32]
			Exhibited higher antioxidant activity in inhibiting the autooxidation of linoleic acid (IC50 of 2.0 μg/mL) than control (dl-a-tocopherol with IC_{50} of 7.7 μg/mL).	Hatano et al. [32]
			Displayed higher radical scavenging activity on DPPH radical (IC50 of 2.4 μg/mL) compared to control (dl-a-tocopherol with IC_{50} of 4.6 μg/mL).	Hatano et al. [32]
102	3-T-*O*-arabinopyranosyl cinnamtannin B1	Antioxidant	Inhibited NADPH-dependent lipid peroxidation in rat liver microsomes with IC_{50} of 28 μg/mL. Control used was dl-a-tocopherol with IC_{50} of 5.6 μg/mL.	Hatano et al. [32]
			Exhibited higher antioxidant activity in inhibiting the autooxidation of linoleic acid (IC50 of 1.9 μg/mL) compared to control (dl-a-tocopherol with IC_{50} of 7.7 μg/mL).	Hatano et al. [32]

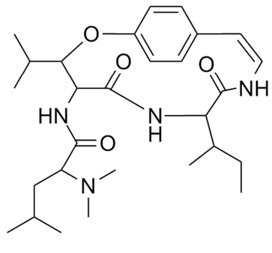
			Displayed higher radical scavenging activity on DPPH radical (IC50 of 2.3 μg/mL) compared to control (dl-a-tocopherol with IC_{50} of 4.6 μg/mL).	Hatano et al. [32]
107	Mansonone C	Cytotoxicity	Exhibited high cytotoxicity against brine shrimp *Artemia salina* Linn. with LC_{50} of 2.08 μg/mL. DMSO was used as standard.	Tiew et al. [30]
110	Mansonone G	Cytotoxicity	Exhibited medium cytotoxicity against brine shrimp *Artemia salina* Linn. with LC_{50} of 64.36 μg/mL. DMSO was used as standard.	Tiew et al. [30]
111	Mansonone H	Cytotoxicity	Exhibited medium cytotoxicity against brine shrimp *Artemia salina* Linn. with LC_{50} of 50.70 μg/mL. DMSO was used as standard.	Tiew et al. [30]
124	3b-hydroxylup-20(29)-en-28-oic acid 3-caffeate	Antitumor	Displayed mild inhibitory activity against SK-MEL-28 cells with IC_{50} of 81.7 μM	Chen et al. [28]
125	Helicteric acid	Antitumor	Displayed mild inhibitory activity against SK-MEL-28 cells with IC_{50} of 32.0 μM	Chen et al. [28]
143	Cucurbitacin D	Antitumor	Significantly inhibited the proliferation of BEL-7402 and and SK-MEL-28 cells with IC_{50} of 1.41 and 1.22 μM, respectively.	Chen et al. [28]
144	Cucurbitacin J	Antitumor	Significantly inhibited the proliferation of BEL-7402 and and SK-MEL-28 cells with IC_{50} of 1.37 and 1.28 μM, respectively.	Chen et al. [28]

FIGURES

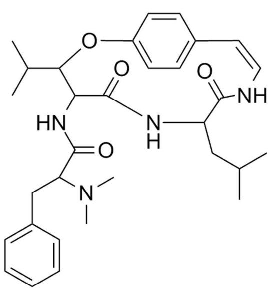
Figure 1. Alkaloids from Sterculiaceae Species



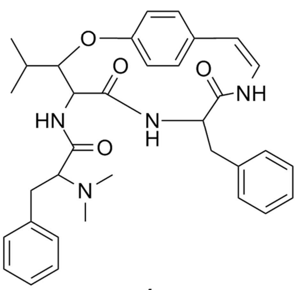
1



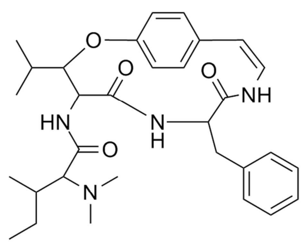
2



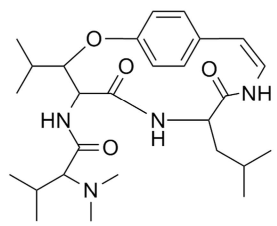
3



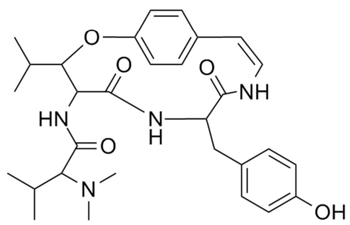
4



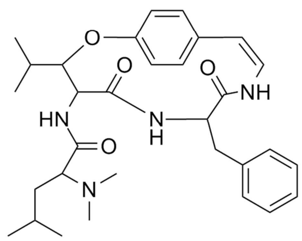
5



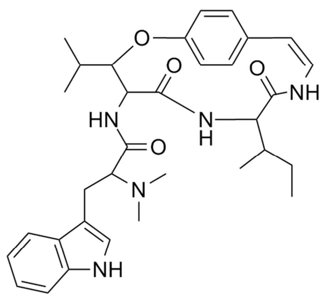
6



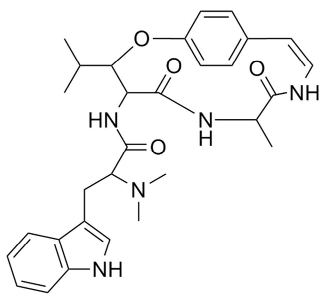
7



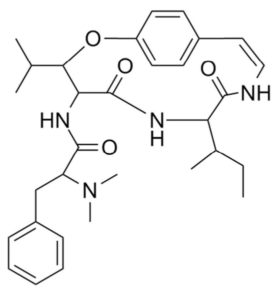
8



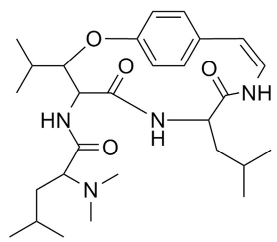
9



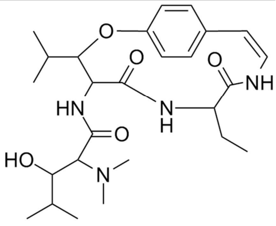
10



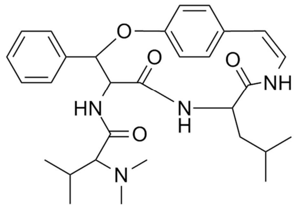
11



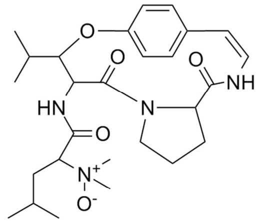
12



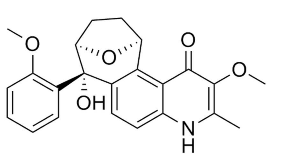
13



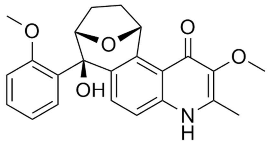
14



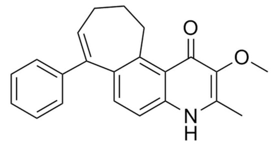
15



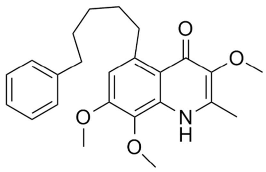
16



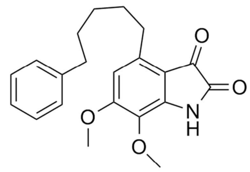
17



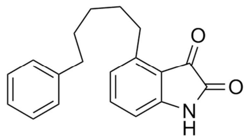
18



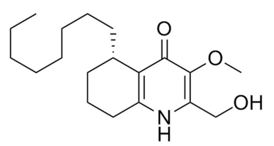
19



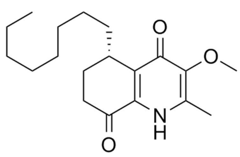
20



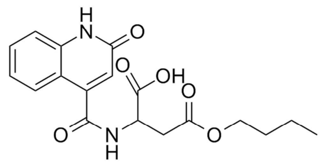
21



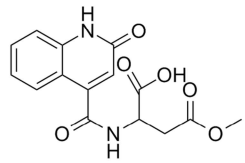
22



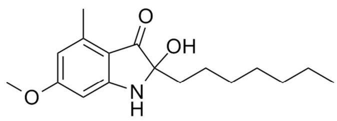
23



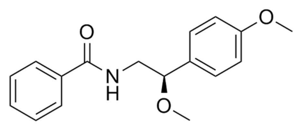
24



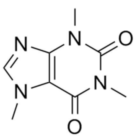
25



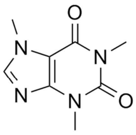
26



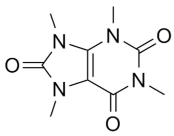
27



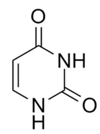
28



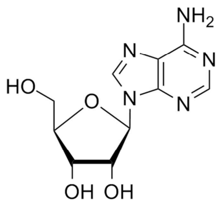
29



30

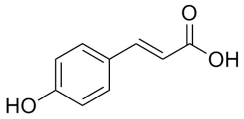


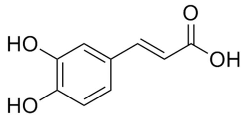
31

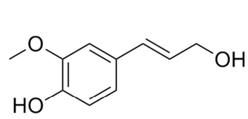


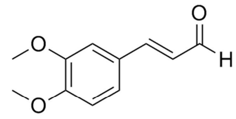
32

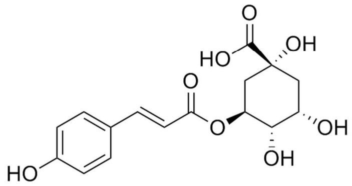
Figure 2. Phenyl Propanoids from Sterculiaceae Species

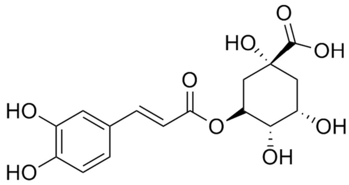

33

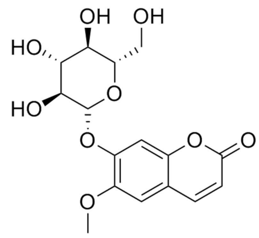

34

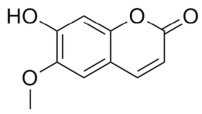

35

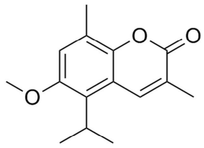

36

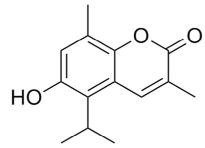

37

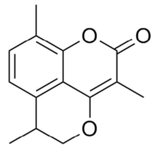

38

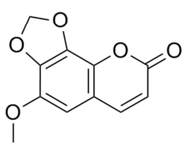

39

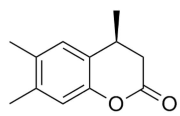

40

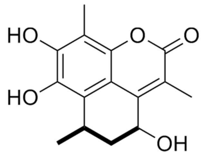

41

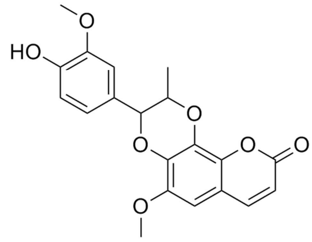

42

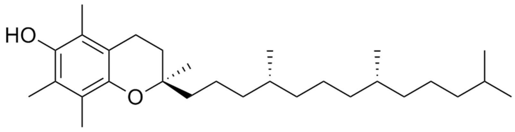

43

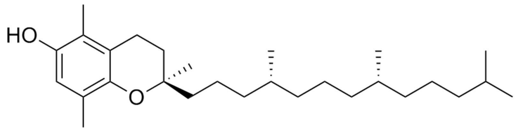

44

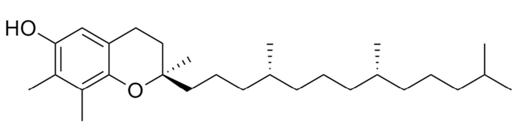

45


46


47


48


49


50

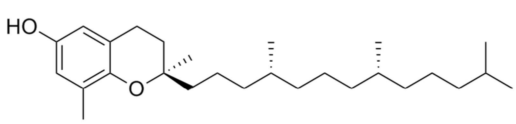
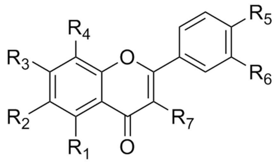
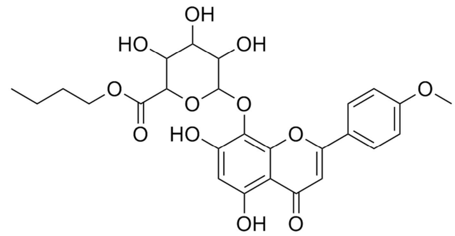

51

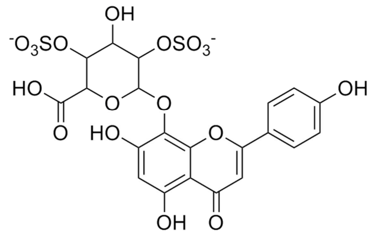
Figure 3. Flavones from Sterculiaceae Species



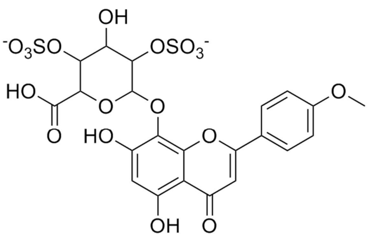
52. R_1=R_3=R_5=OH; R_2=R_4=R_6=R_7=H
53. R_1=R_2=R_4=OH; R_2=R_4=R_7=H; R_6=OCH_3
54. R_1=R_5=R_7=OH; R_2=R_4=R_6=H; R_3=*O*-Glucoside
55. R_1=R_5=R_7=OH; R_2=R_4=R_6=H; R_3=*O*-Neohesperidoside
56. R_1=R_3=R_5=R_6=OH; R_2=R_4=R_7=H
57. R_1=R_5=R_6=R_7=OH; R_2=R_4=H; R_3=*O*-Glucoside
58. R_1=R_5=R_6=R_7=OH; R_2=R_4=H; R_3=*O*-Neohesperidoside
59. R_1=R_4=OH; R_2=R_6=R_7=H; R_3=R_5=OCH_3
60. R_1=R_3=R_5=R_6=OH; R_2=R_4=H; R_7=*O*-Glucoside
61. R_1=R_3=R_5=R_6=OH; R_2=R_4=H; R_7=*O*-Galactoside
62. R_1=R_3=R_5=R_6=OH; R_2=R_4=H; R_7=*O*-Arabinoside
63. R_1=R_3=R_5=OH; R_2=R_4=R_6=H; R_7=*O*-Glucoside
64. R_1=R_3=R_5=OH; R_2=R_4=R_6=H; R_7=*O*-Rutinoside
65. R_1=R_3=R_5=OH; R_2=R_6=R_7=H; R_4=*O*-Glucoside
66. R_1=R_3=R_5=OH; R_4=R_6=R_7=H; R_2=*O*-Glucoside
67. R_1=R_5=OH; R_2=R_4=R_7=H; R_6=OCH_3; R_3=*O*-Glucoside
68. R_1=R_3=R_5=OH; R_2=R_4=H; R_6=OCH_3; R_7=*O*-Rutinoside
69. R_1=R_3=R_6=OH; R_2=R_7=H; R_5=OCH_3; R_4=*O*-Glucuronic Acid
70. R_1=R_3=R_6=OH; R_4=R_5=R_7=H; R_2=*O*-Glucoside
71. R_1=R_3=OH; R_2=R_6=R_7=H; R_5=OCH_3; R_4=*O*-Glucuronic Acid



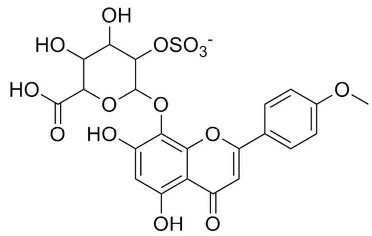
72



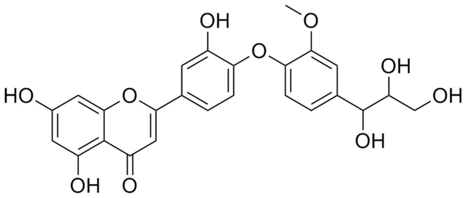
73



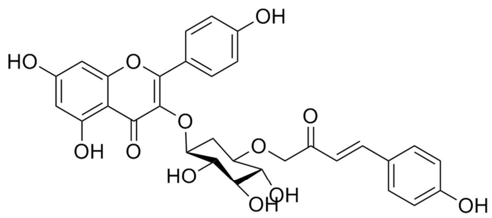
74



75

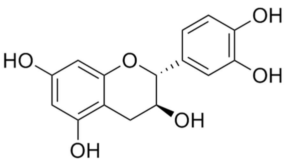


76

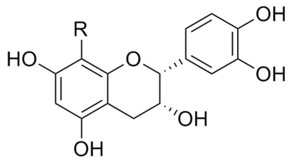


77

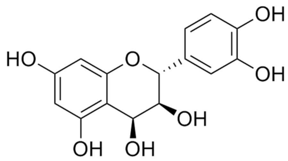
Figure 4. Flavans from Sterculiaceae Species



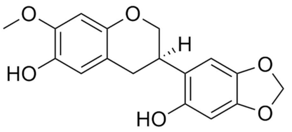
78



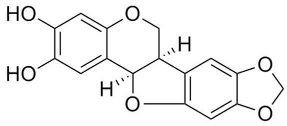
79. R=H
80. R=Galactoside



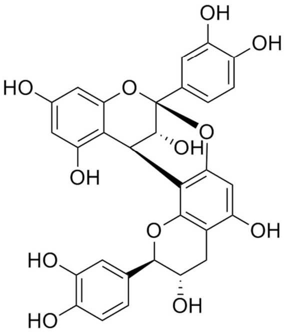
81



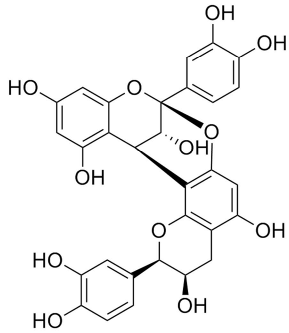
82



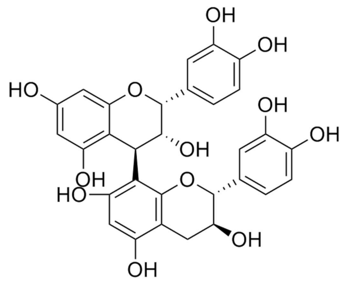
83



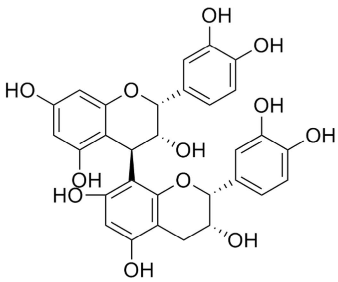
84



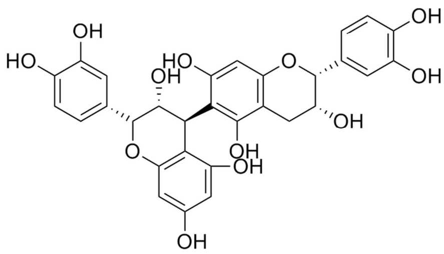
85



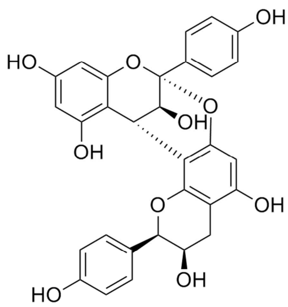
86



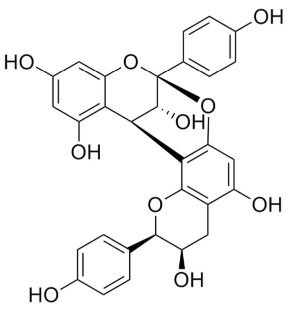
87



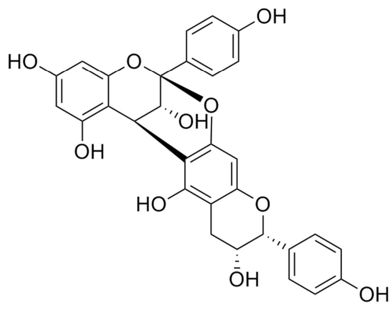
88



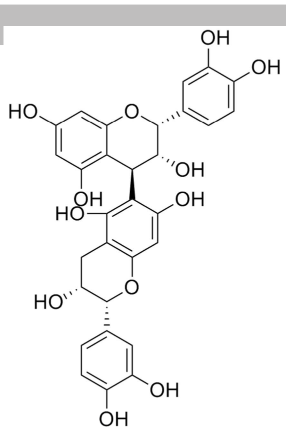
89



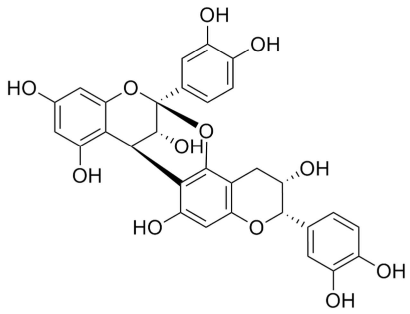
90



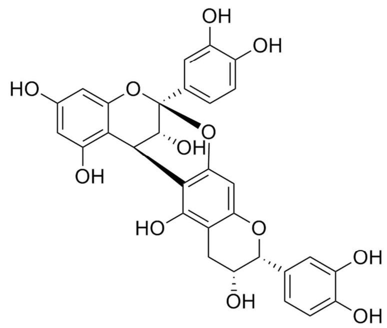
91



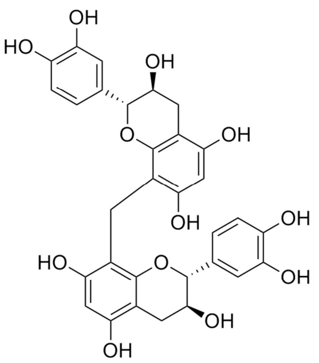
92



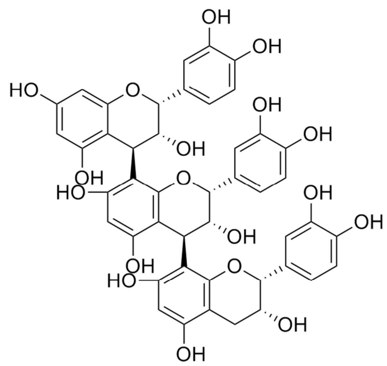
93



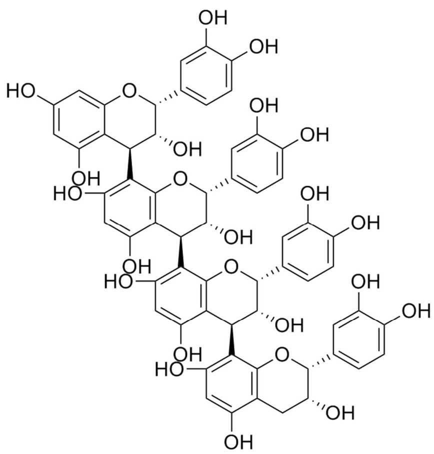
94



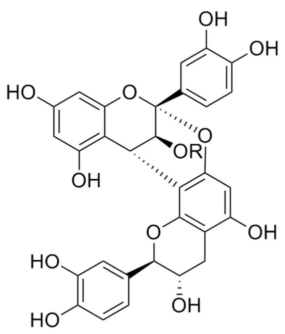
95



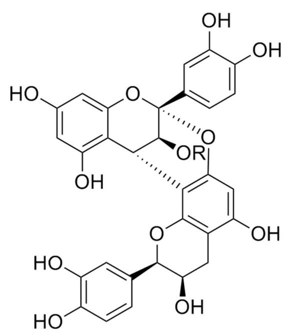
96



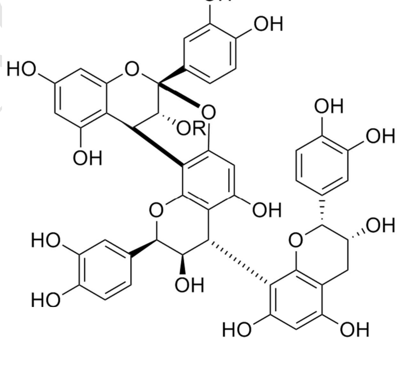
97



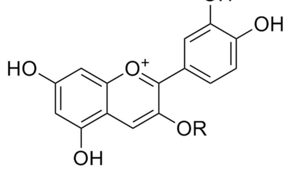
98. R = Arabinoside



99. R = Galactoside
100. R = Arabinoside

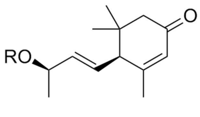


101. R = Galactoside
102. R = Arabinoside

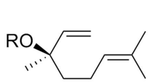


103. R = Galactoside
104. R = Arabinoside

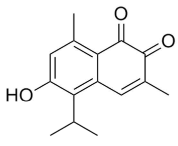
Figure 5. Terpenoids from Sterculiaceae Species



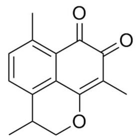
105. R = Glucoside



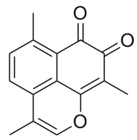
106. R = Rutinoside



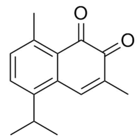
107



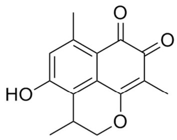
108



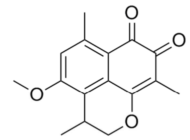
109



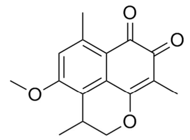
110



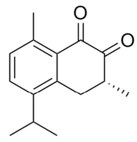
111



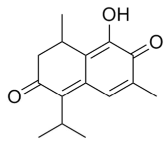
112



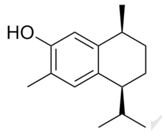
113



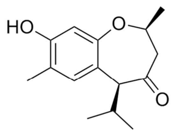
114



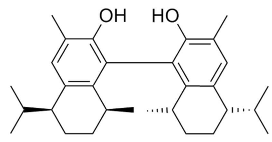
115



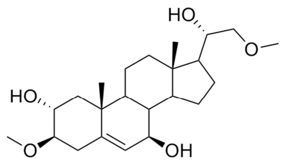
116



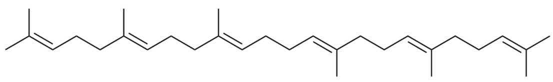
117



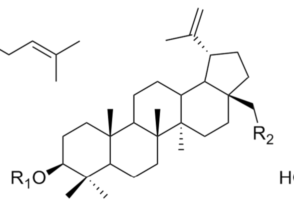
118



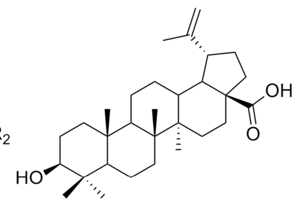
119



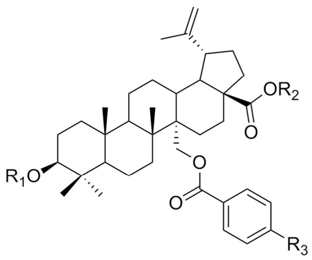
120



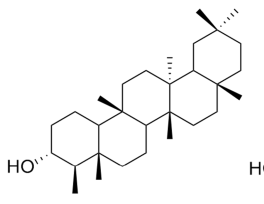
121. R_1=R_2=H
122. R_1=Acetate; R_2=OH



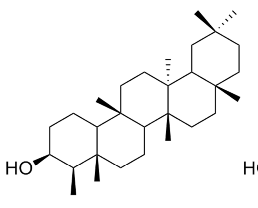
123. R=H
124. R=Caffeate



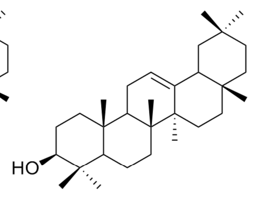
125. R_1=Acetate; R_2=R_3=H
126. R_1=Acetate; R_2=CH_3, R_3=H
127. R_1=Acetate; R_2=CH_3, R_3=OH
128. R_1=OH; R_2=CH_3, R_3=H



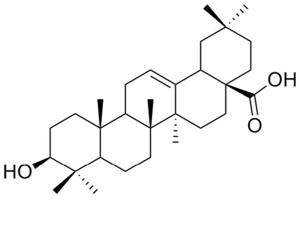
129



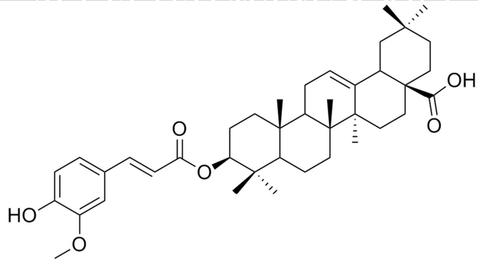
130



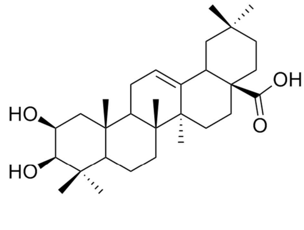
131



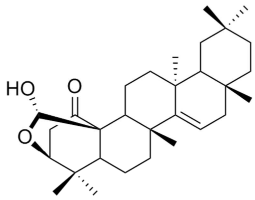
132



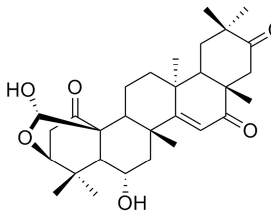
133



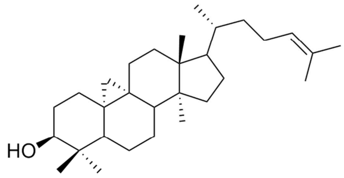
134



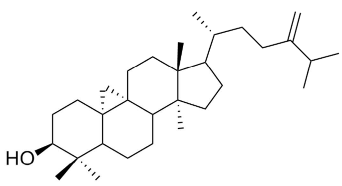
135



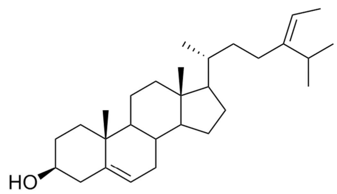
136



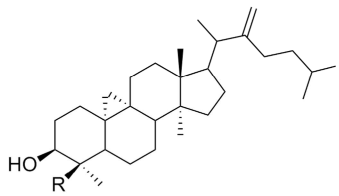
137



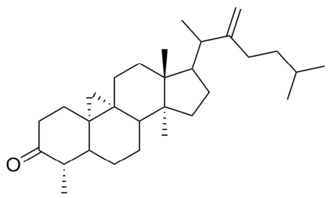
138



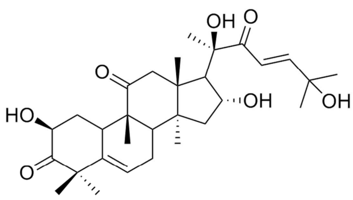
139



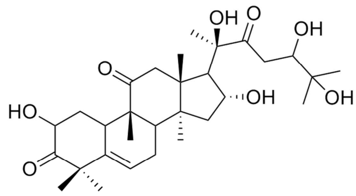
140. R=CH_3
141. R=H



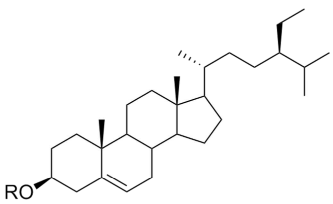
142



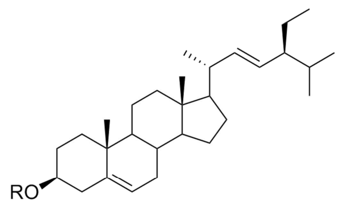
143



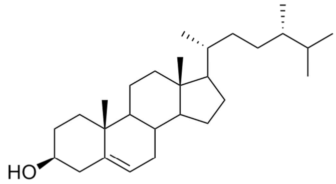
144



145. R = H
146. R = Ac

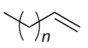


147. R = H
148. R = Glucose

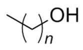


149

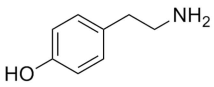
Figure 6. Miscellaneous Compounds from Sterculiaceae Species



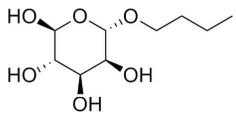
150. n = 8
151. n = 25



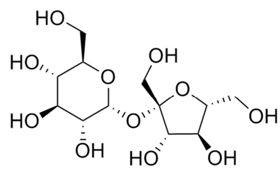
152. n = 21
153. n = 27



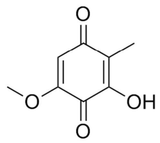
154



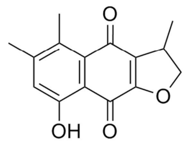
155



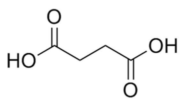
156



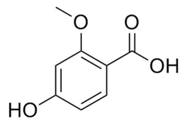
157



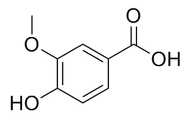
158



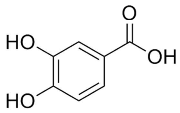
159



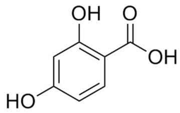
160



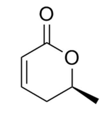
161



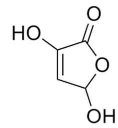
162



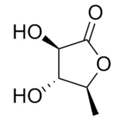
163



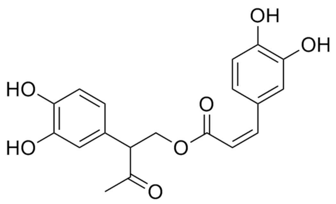
164



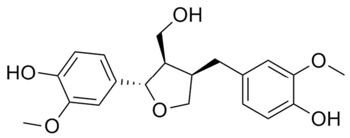
165



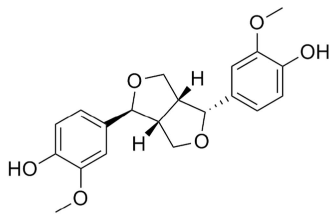
166



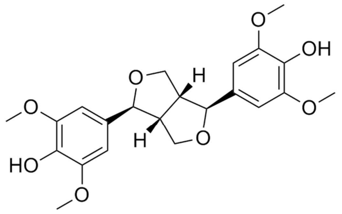
167



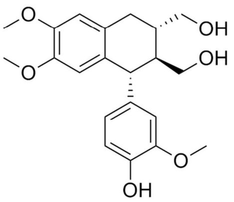
168



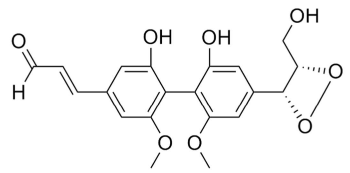
169



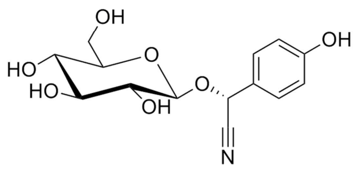
170



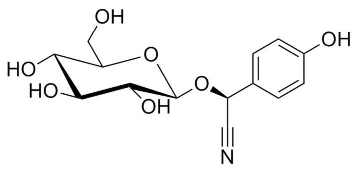
171



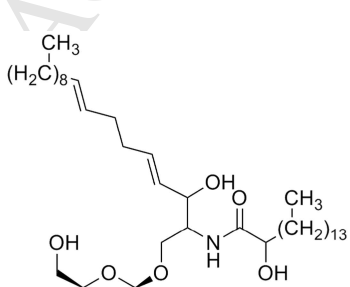
172



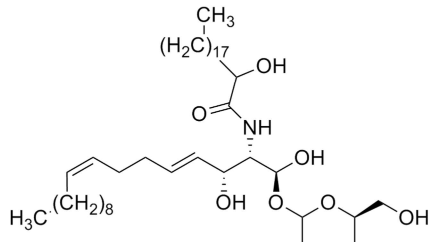
173



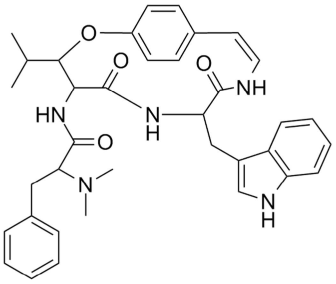
174



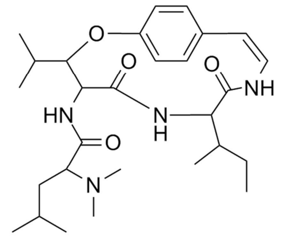
175



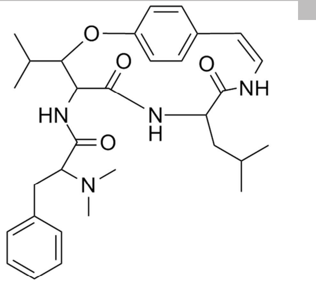
176



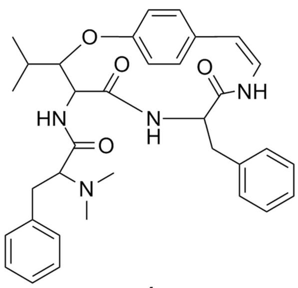
1



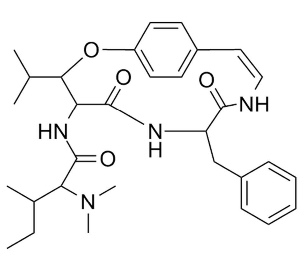
2



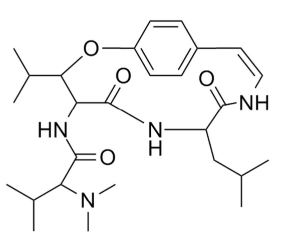
3



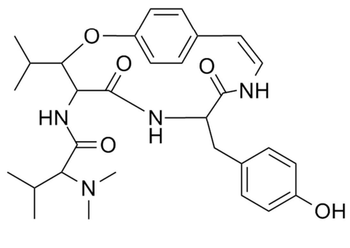
4



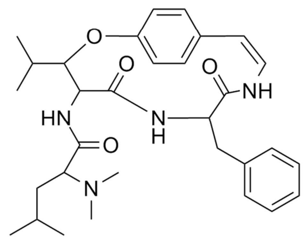
5



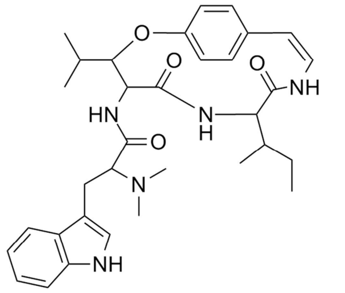
6



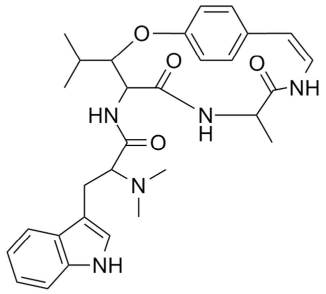
7



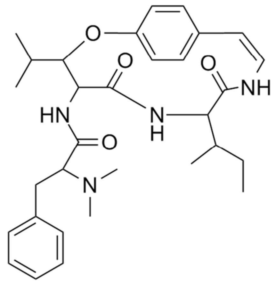
8



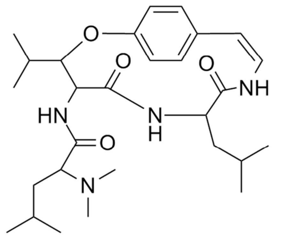
9



10



11



12

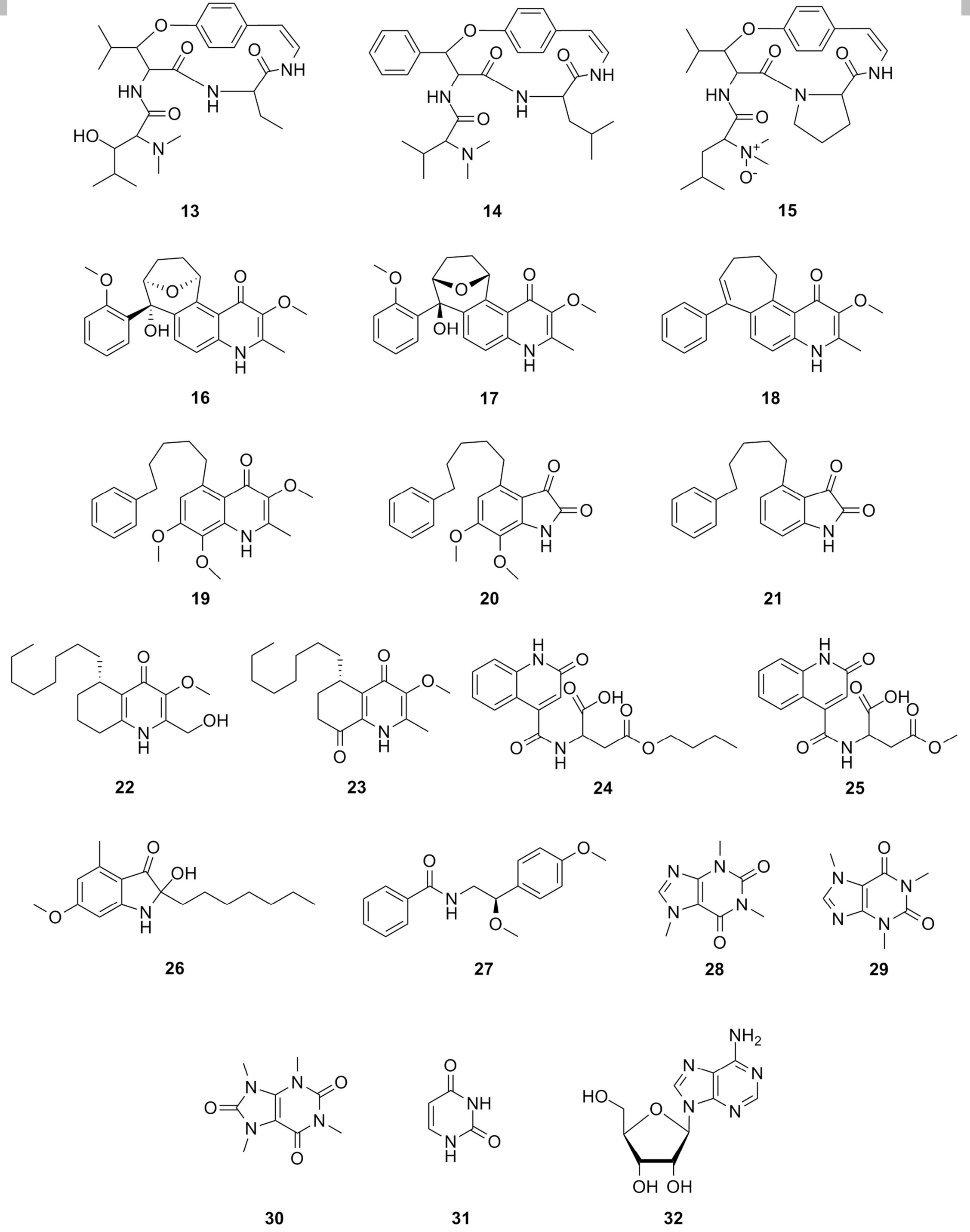
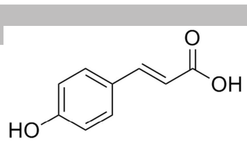
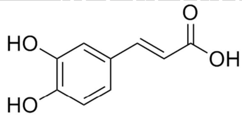


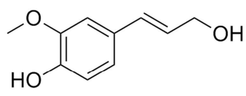
Figure 1. Alkaloids from Sterculiaceae Species



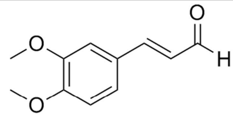
33



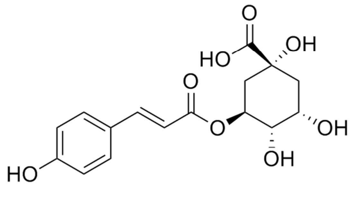
34



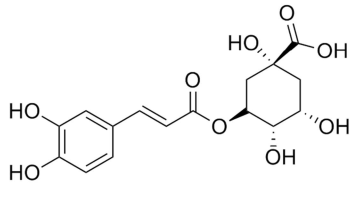
35



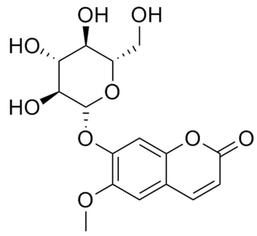
36



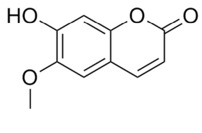
37



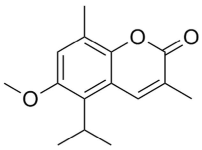
38



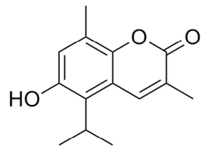
39



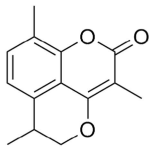
40



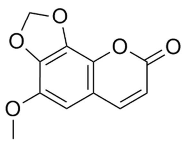
41



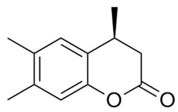
42



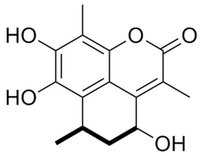
43



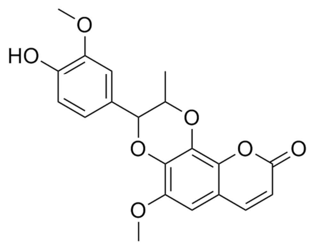
44



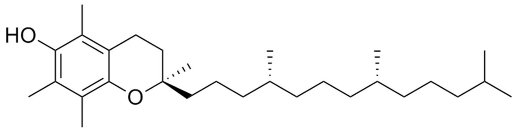
45



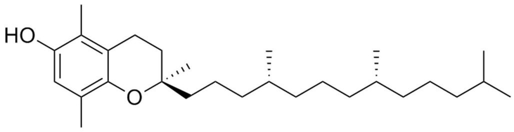
46



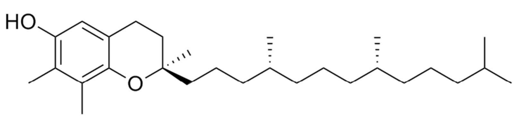
47



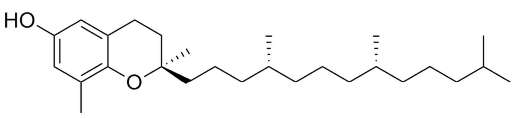
48



49

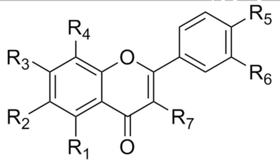


50

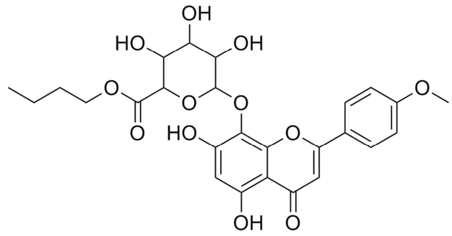


51

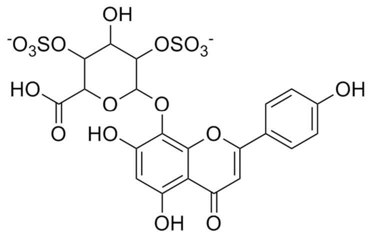
Figure 2. Phenyl Propanoids from Sterculiaceae Species



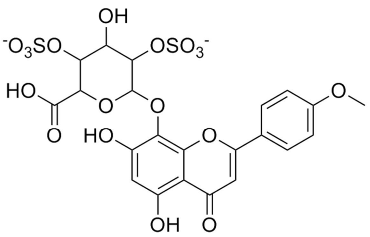
52. $R_1=R_3=R_5=OH$; $R_2=R_4=R_6=R_7=H$
53. $R_1=R_2=R_4=OH$; $R_2=R_4=R_7=H$; $R_6=OCH_3$
54. $R_1=R_5=R_7=OH$; $R_2=R_4=R_6=H$; R_3=*O*-Glucoside
55. $R_1=R_5=R_7=OH$; $R_2=R_4=R_6=H$; R_3=*O*-Neohesperidoside
56. $R_1=R_3=R_5=R_6=OH$; $R_2=R_4=R_7=H$
57. $R_1=R_5=R_6=R_7=OH$; $R_2=R_4=H$; R_3=*O*-Glucoside
58. $R_1=R_5=R_6=R_7=OH$; $R_2=R_4=H$; R_3=*O*-Neohesperidoside
59. $R_1=R_4=OH$; $R_2=R_6=R_7=H$; $R_3=R_5=OCH_3$
60. $R_1=R_3=R_5=R_6=OH$; $R_2=R_4=H$; R_7=*O*-Glucoside
61. $R_1=R_3=R_5=R_6=OH$; $R_2=R_4=H$; R_7=*O*-Galactoside
62. $R_1=R_3=R_5=R_6=OH$; $R_2=R_4=H$; R_7=*O*-Arabinoside
63. $R_1=R_3=R_5=OH$; $R_2=R_4=R_6=H$; R_7=*O*-Glucoside
64. $R_1=R_3=R_5=OH$; $R_2=R_4=R_6=H$; R_7=*O*-Rutinoside
65. $R_1=R_3=R_5=OH$; $R_2=R_6=R_7=H$; R_4=*O*-Glucoside
66. $R_1=R_3=R_5=OH$; $R_4=R_6=R_7=H$; R_2=*O*-Glucoside
67. $R_1=R_5=OH$; $R_2=R_4=R_7=H$; $R_6=OCH_3$; R_3=*O*-Glucoside
68. $R_1=R_3=R_5=OH$; $R_2=R_4=H$; $R_6=OCH_3$; R_7=*O*-Rutinoside
69. $R_1=R_3=R_6=OH$; $R_2=R_7=H$; $R_5=OCH_3$; R_4=*O*-Glucuronic Acid
70. $R_1=R_3=R_6=OH$; $R_4=R_5=R_7=H$; R_2=*O*-Glucoside
71. $R_1=R_3=OH$; $R_2=R_6=R_7=H$; $R_5=OCH_3$; R_4=*O*-Glucuronic Acid



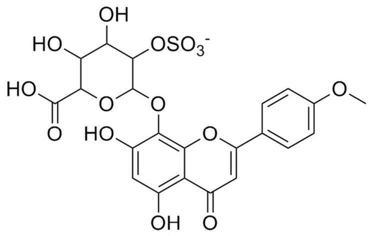
72



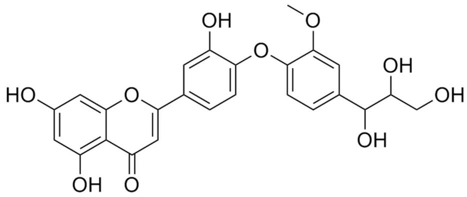
73



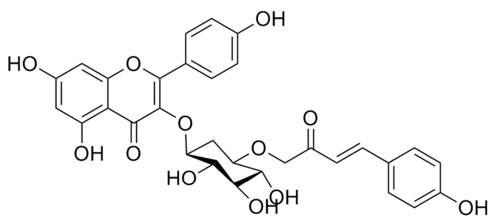
74



75

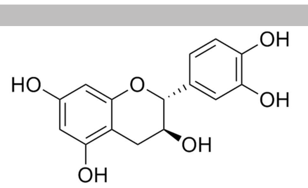


76

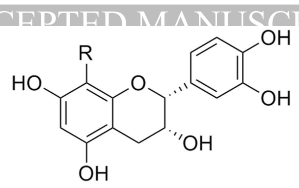


77

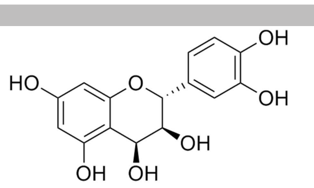
Figure 3. Flavones from Sterculiaceae Species



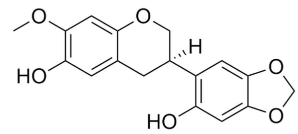
78



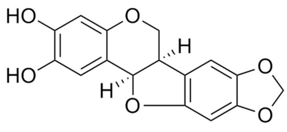
79. R=H
80. R=Galactoside



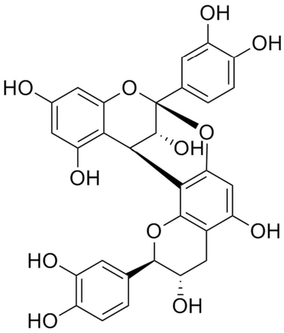
81



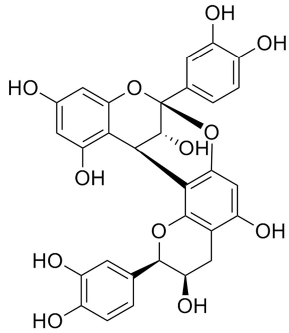
82



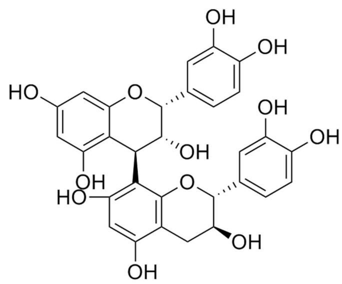
83



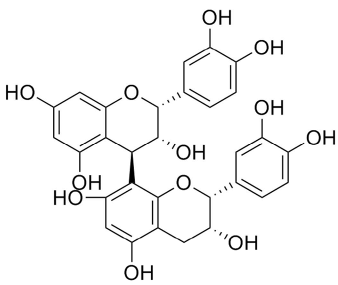
84



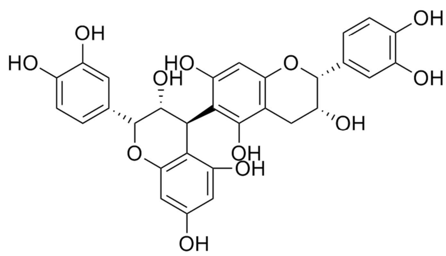
85



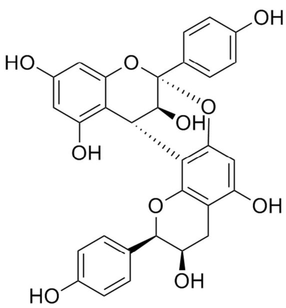
86



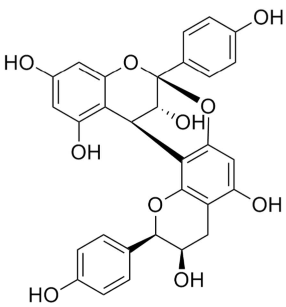
87



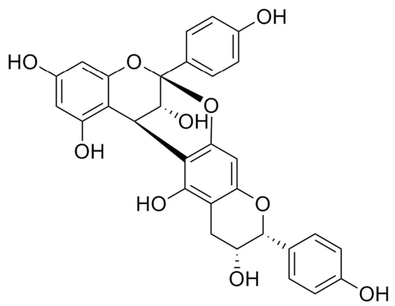
88



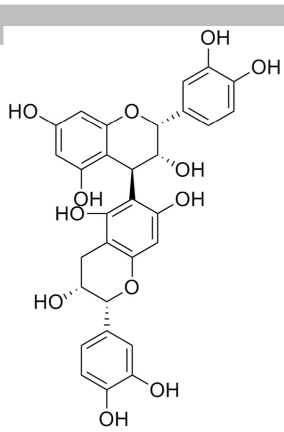
89



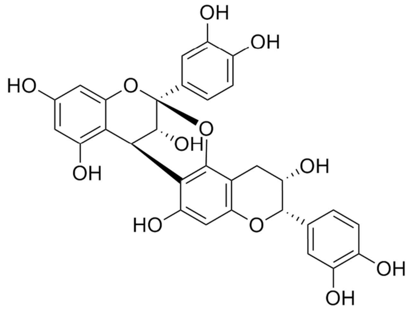
90



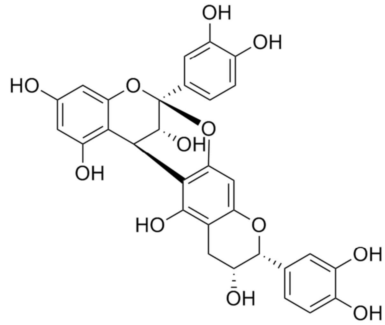
91



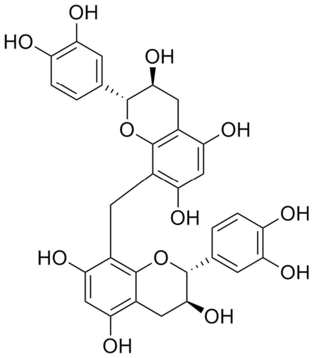
92



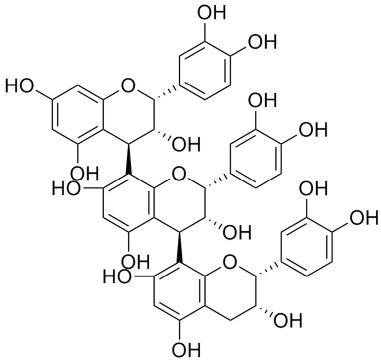
93



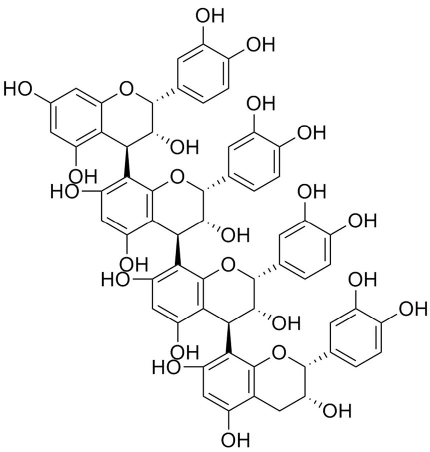
94



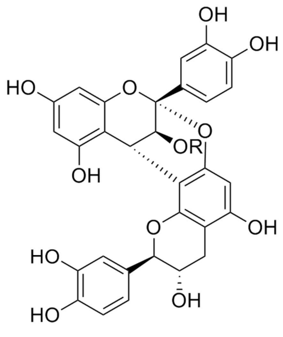
95



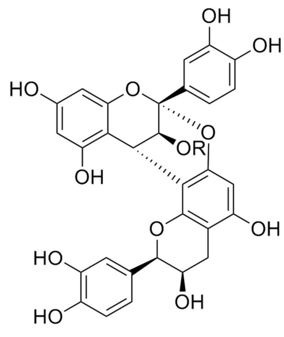
96



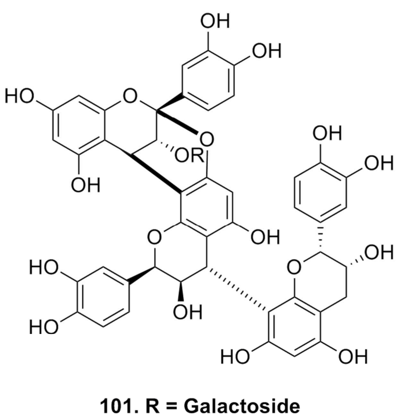
97



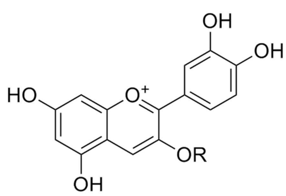
98. R = Arabinoside



99. R = Galactoside
100. R = Arabinoside

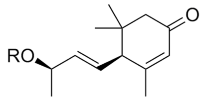


101. R = Galactoside
102. R = Arabinoside

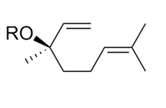


103. R = Galactoside
104. R = Arabinoside

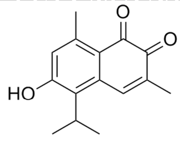
Figure 4. Flavans from Sterculiaceae Species



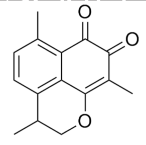
105. R = Glucoside



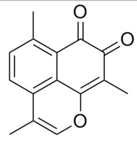
106. R = Rutinoside



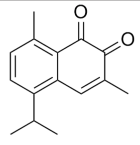
107



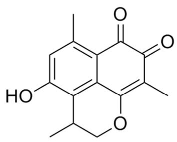
108



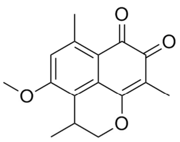
109



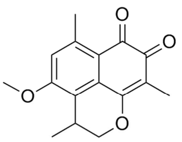
110



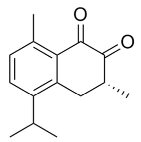
111



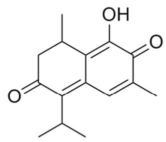
112



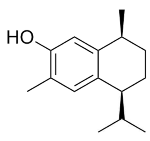
113



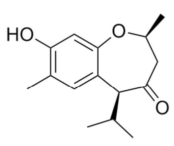
114



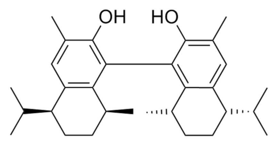
115



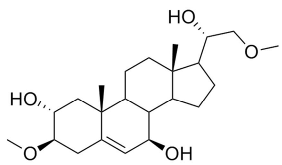
116



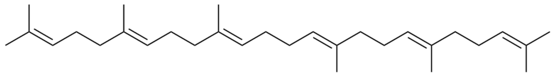
117



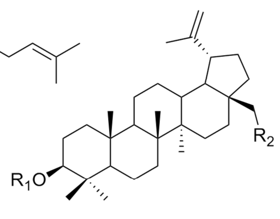
118



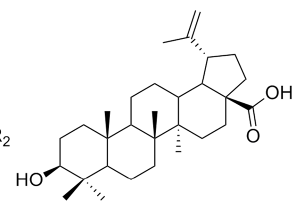
119



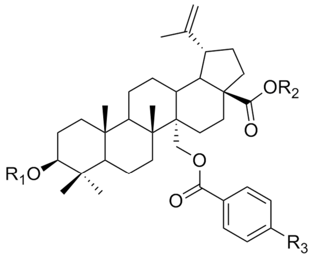
120



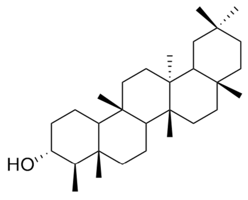
121. R_1=R_2=H
122. R_1=Acetate; R_2=OH



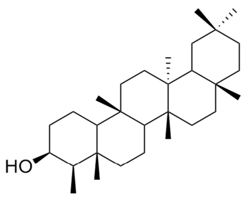
123. R=H
124. R=Caffeate



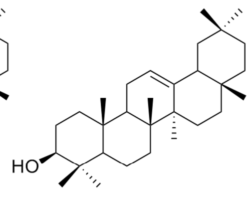
125. R_1=Acetate; R_2=R_3=H
126. R_1=Acetate; R_2=CH_3, R_3=H
127. R_1=Acetate; R_2=CH_3, R_3=OH
128. R_1=OH; R_2=CH_3, R_3=H



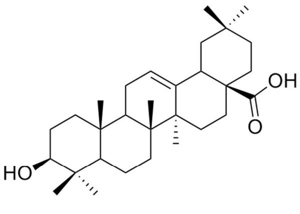
129



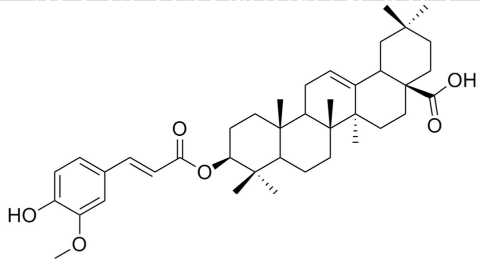
130



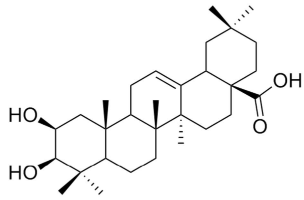
131



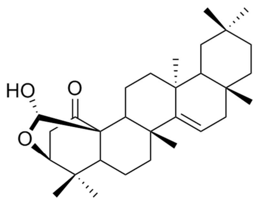
132



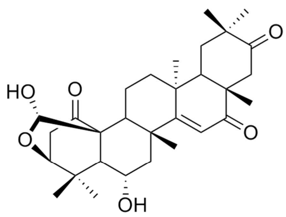
133



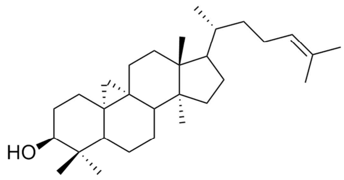
134



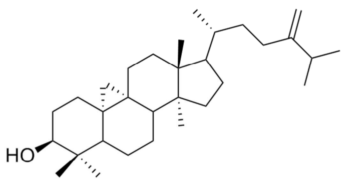
135



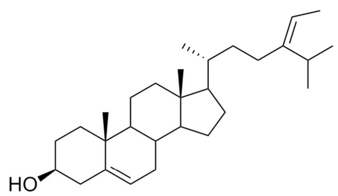
136



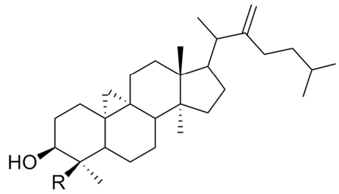
137



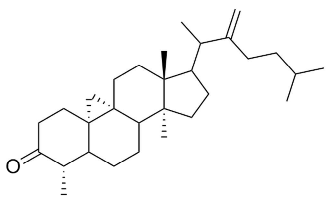
138



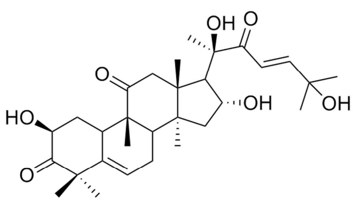
139



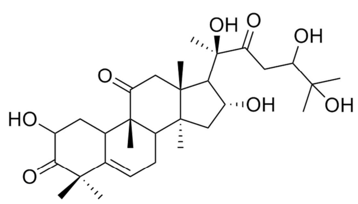
140. R=CH_3
141. R=H



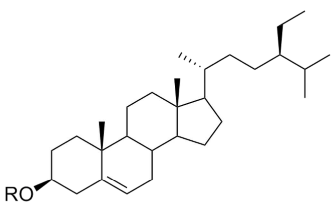
142



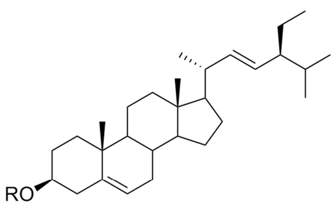
143



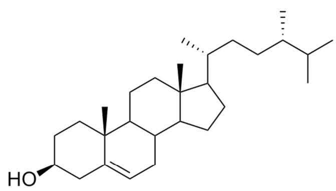
144



145. R = H
146. R = Ac



147. R = H
148. R = Glucose



149

Figure 5. Terpenoids from Sterculiaceae Species

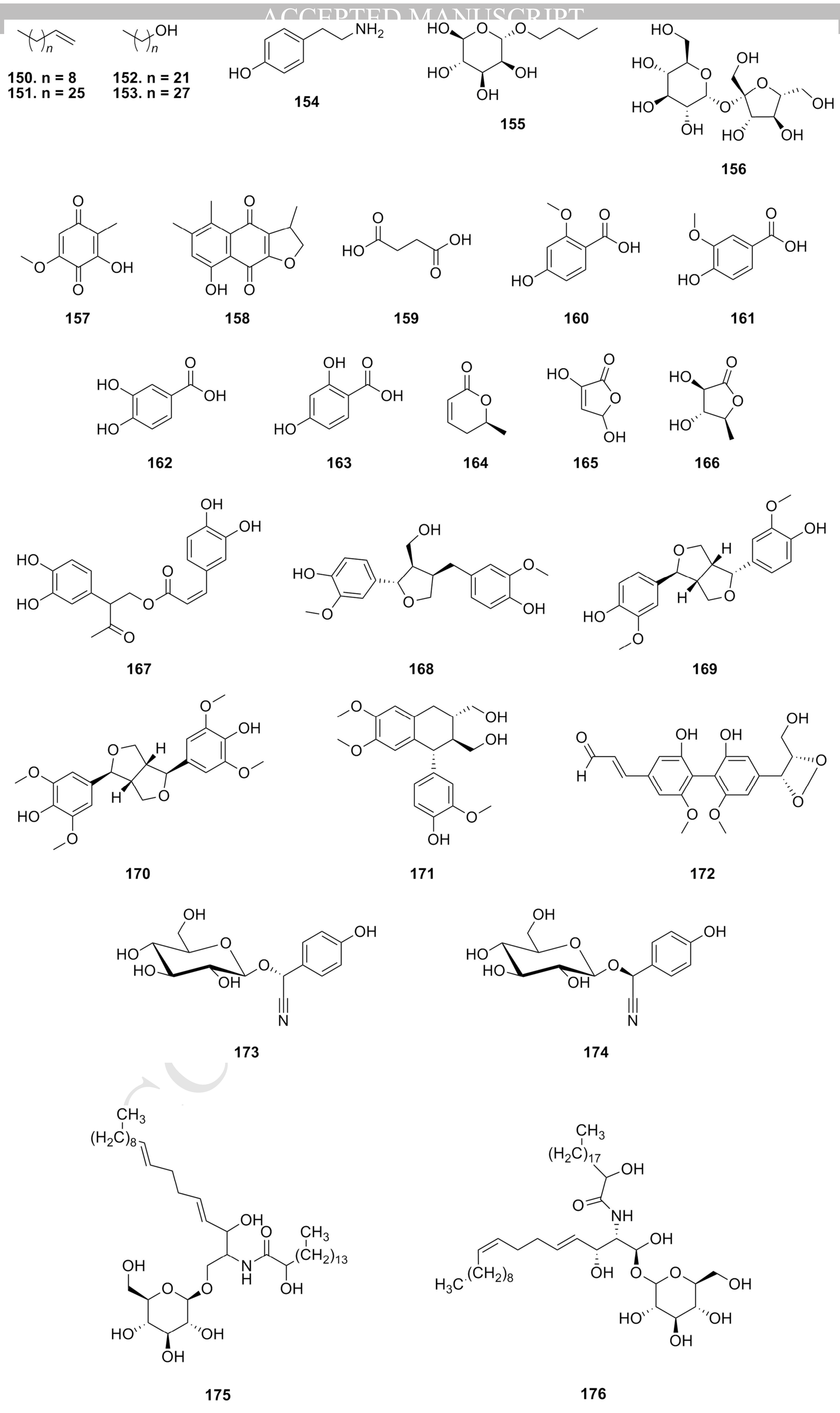


Figure 6. Miscellaneous Compounds from Sterculiaceae Species

Highlights

- Plants from family Sterculiaceae aree known to possess various medicinal properties
- Alkaloids, flavonoids and terpenoids are the most dominant compounds in this family
- The plants show biological activities such as antimicrobial and cytotoxic activities